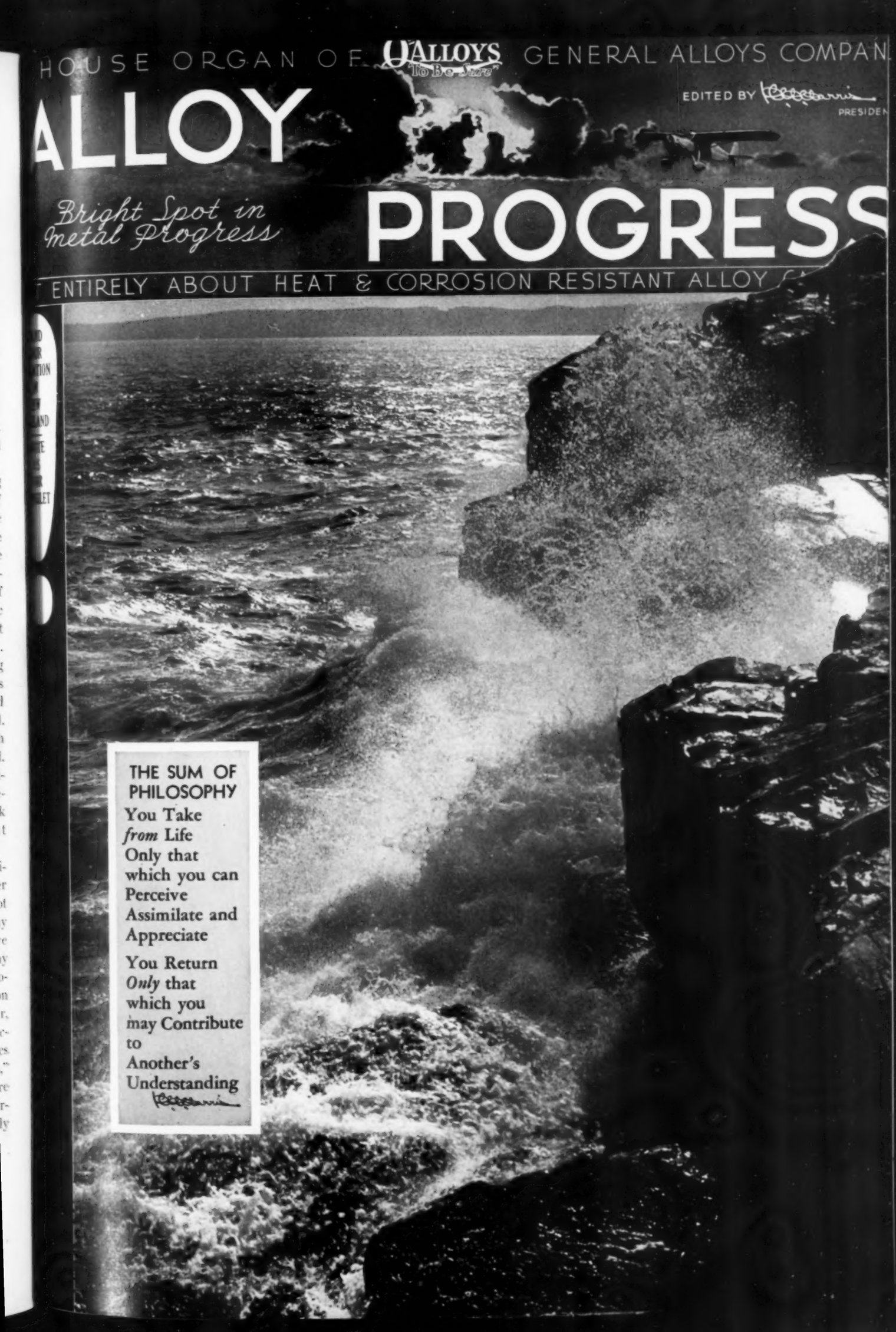
HOUSE ORGAN OF ALLOYS "To Be Sure" GENERAL ALLOYS COMPAN

EDITED BY [illegible]
PRESIDEN

ALLOY PROGRESS

Bright Spot in Metal Progress

ENTIRELY ABOUT HEAT & CORROSION RESISTANT ALLOY



THE SUM OF PHILOSOPHY

You Take
from Life
Only that
which you can
Perceive
Assimilate and
Appreciate

You Return
Only that
which you
may Contribute
to
Another's
Understanding

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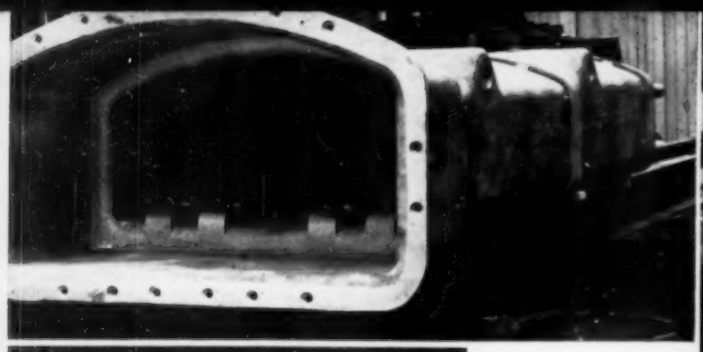


T.O.M. Sopwith's Endeavour I at Herreshoff's Yard, Bristol, R. I.
HHH Photo

The little bundle third-way up the mast is a man.

IF pictures appeal to you, try and remember a better one than our cover this issue. A lot of thought, study and thirst for truth is distilled to my few words on that picture. If you want a copy, unfolded, write for it. Also write for Booklet "Your Vacation in New England."

MY yen for philosophy began early. Aged six, at Ormond Beach, Florida, I querried my true-blue-black "Mammy." "Aunty Posey," I asked, "is it true that little Boys are made of Snakes and Snails and Puppy-dogs' tails, and little Girls are made of Sugar and Spice and every thing nice?" . . . "Wal, Honey Chile, it takes two-uns to make a sin,—so—either deres jus' as *menny* little gals a sinnin' as little boys, or them as does sin, sins *double*" A Pearl of Wisdom from a Mountain of humanity. *The mathematics of morality.*

"MIKE" Vanderbilt's Ranger is busy proving herself in trial races, against Yankee and Rainbow, as the logical defender of the America's Cup. T.O.M. Sopwith, British Challenger, now sailing trials on his two Endeavours, is much perturbed because Ranger has no bathtub, and threatens to pull the "blooming bawths" from his Endeavours.

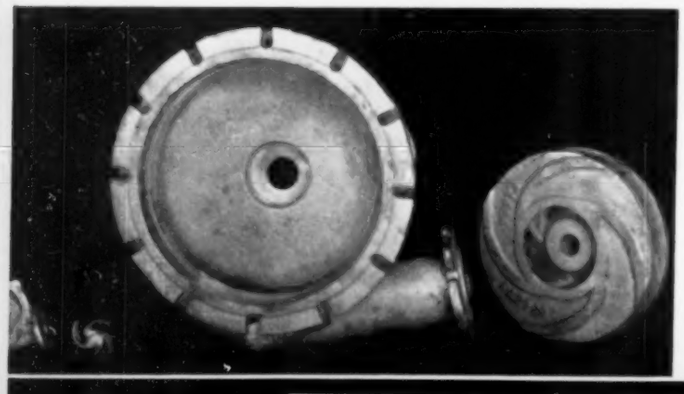
EVEN an extra ounce of weight may mean defeat in the forthcoming race for that "World's most coveted Trophy," costing only $500, but inspiring the expenditure of many millions. Extra weight is also costly in alloy parts, which often cost much *more to run* because they cost *less to buy*. Railroads, we are told, are not run with dollar watches.

Sea Steel Marine Fittings

The small blocks and special fittings shown below are but a few of thousands or more Sea Steel patterns. Sea Steel is a Super Stainless Steel, exceeding U. S. Navy Specifications, developed by General Alloys and specified on the finest yachts afloat.

CORROSION RESISTANT CASTINGS

he large pump impeller shown below is a "Triple Vein" ype, a closed impeller with veins inside and out, an engieering foundry job. The small one is a pocket size overung impeller "Swastika" model. Both are Q-Alloy CN 1.



YACHTING supports the finest group of craftsmen in America. Herreshoff's, at Bristol, R. I., Lawley's at Neponset, Mass., Bath Iron Works at Bath, Me., all world famous yacht builders, carry forward the traditions of world champions for generations. Such New England Craftsmanship, enhances the products of such companies as Pratt & Whitney, Brown & Sharpe, General Alloys, permitting jobbing manufacture on a precision and quality basis, and supplying tools that control quality in the production industries. Lawley and Herreshoff have standardized on General Alloys SEA STEEL marine fittings. Note the fittings illustrated as far above steel foundry practice as to making excells blacksmithing. Polished castings must be clean metal. Metallurgical cleanliness, first perfected in Q-Alloys extend fatigue resistance, places General Alloys beyond competition.

I RECENTLY heard a beautiful set of bells a five octave Carillon which plays selections from Carmen at high-noon from the bell tower of Chas. B. King's unique estate at Larchmont. Mr. King has a re between a castle, a museum, India House and the Patent Office. Imagine a hundred working models of intricate steam and gas line engines, a one-quarter scale steam tra tor, an eighth scale locomotive, Chine

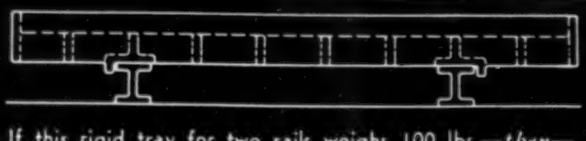
"SLATS" SLENSBY & MAJOR

cannon, Spanish bells, ship models and ra brocades, Italian iron, and Flemish wo carving, all this, reams, tons, and scads it, filling rooms of a huge rambling hou with store-size plate glass windows ov looking the sound, and an old-world pat King abhors the commonplace, even "Re-snouting" a Lincoln Zephyr, with ho and cowling a la King. I haven't had su a kick out of anything since that Germa industrial museum of 100% working mode

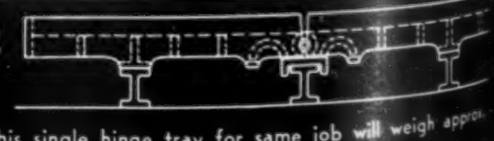
"RINGS like a Bell" has always been b of G. A. Castings but now the dema for our bells is increasing, yacht bells, lo motive bells, ships' bells. One just supp to A. Atwater Kent of Philadelphia for h yacht "Dolphin," is illustrated. It goes w matching Sea Steel Fittings.

"SLATS" Slensby, who gives techn Alloys unequalled representation Milwaukee, came into Boston last week h dope on our new trays and furnace mod nisms. "Slats" is here pictured rough-hou ing Major, who reports "Okay." Right his heels came "Jerry" Donovan from Ch cago, who claims he has had only "vacations" in his eighteen years with G eral Alloys, and is now staging "Honeymo No. 3" with Mrs. J. to N. Y., N. E. a Canada.

CHECK THESE SAVINGS



If this rigid tray for two rails weighs 100 lbs.—*then*—



This single hinge tray for same job will weigh appro

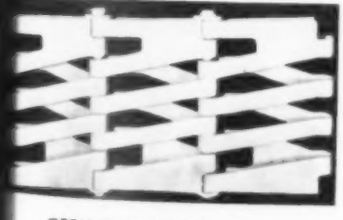
"There is No Substitute for Experience"

Alloy Casting Manufacturer Approximates GA Experience

POP LINDBERG WILL LEAD WHEEL CHAIR PARADE AT ATLANTIC CITY STEEL SHOW, Oct. 18-22

ALLOY and X-ite cast chain is replacing forged chain at high temperatures for obvious reasons. The softer, high elongation alloys which forge easily, also stretch easily, are too soft for maximum wear. If forged chain is "getting-by," a lighter, stronger G. A. cast chain will do the work. This writer has just been allowed a Patent on a process of coating the interior of carburizing containers with metals and alloys to retard carbon penetration, thus materially retarding the embrittlement and fatigue failure of thin-wall carburizing containers. This process, proven in large installations, will add materially to the life of those thin cast Alloy boxes which have already cut the cost-hour cost of sheet boxes about 40%.

THE death of George H. Porter, of Cleveland, leaves another large gap in the ranks of Old Time Steel Treaters, those stalwarts "who brought science to blacksmiths" so that the smaller steel user could compete in quality and precision with the big laboratory controlled plant."



OPEN FACE SPIRALINK

THE August cover we will reveal the Eagle-Ass and the Eliphlop, two charming miscegenations comprising our first, and probably last, political cartoon.

NILS NILSON is now in Germany, having been sent from International Harvester Motor Works to I.H.C. German Works to give the boys pointers on getting lowest-heat-costs, and maximum results, from heat-treatment, and bring back data on Nordicing. With Nils Nordicing around reducing induction hardening, a good time should be had by all.

EDITORIAL in Boston Traveler: "Today being Fathers' day, no doubt the occasion requires editorial comment. After long consideration of the subject we have come to the conclusion that this newspaper is in favor of Fathers and believe they should be continued."

NEW OPEN FACE SPIRALINK. There is now available, under the Spiralink patent, a new X-ite conveyor hearth of exceptionally light weight with 95% of its cross sectional area in tension. Clearances are opened up from the 1/16" or ⅛" of the Standard Spiralink to one, two, or three inches, with pitch from three inches up. Ideal heat transmission and the most durable conveyor known for handling medium size work that won't fall through the spaces.

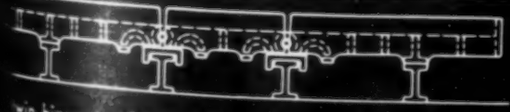
START that build-up with the Boss, now, so he'll send you to the Steel Show in October at Atlantic City.

J. J. DONOVAN

REFRESHINGLY unique is the bulletin of the Wesley Steel Treating Company, of Milwaukee, in which Charles Wesley, Jr., succeeding upon the untimely death of his father to Presidency of his company, pledges himself and his associates to Carry-on under photographs of the late Charles Wesley, Sr., at *work* and at *play*. Informal, human, virile stuff. With permission we reproduce photo of Mr. Wesley, Sr., always a great kidder, standing by a stuffed fish with rod in hand. A most appropriate memento of a regular guy.

A "COMPETITIVE" salesman who doesn't believe in his company buying A.S.M. advertising because he can't drink it, was apologizing for his "low" prices; "Our stuff otta cost less than General Alloys, lukkut that bird Harris flying around in airplanes, somebody has to pay for that." That particular salesman's grandchildren may fly airplanes, if crossed with a stronger breed; meanwhile maybe you'd like to economize by trading your car in on a plane. Facts: Toledo to Milwaukee, 2 Hrs. 20 Min. on 20 gals. of gas. Just modern transportation, 8c per mile.

If you are an A.S.M. member living in Dayton, Columbus, Worcester, or Peoria we will send you an 8x10 enlargement of the above picture of your city, on request, with our compliments. Above Skyviews flown and photographed by H. H. H.



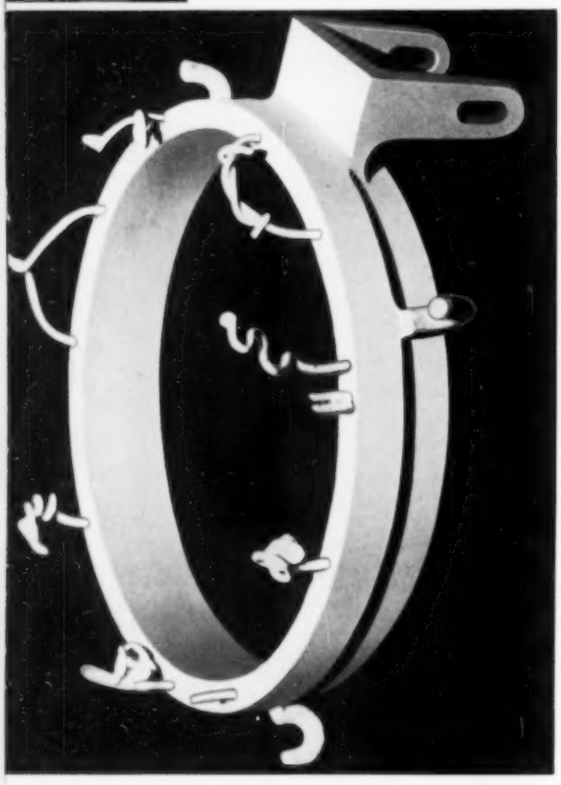
win hinge 4-rail tray will weigh approximately 60 lbs.

A three hinge 5-rail tray will weigh approximately 48 lbs.

THE SAVING IS OBVIOUS

Q-ALLOYS THE QUALITY NAMES IN ALLOY FOR HEAT CORROSION ABRASION X-ite

Merrill & Lambie with their ocean spanning plane powered by Pratt & Whitney Motors. Pratt & Whitney Motors are made from parts carburized and heat-treated in Q-Alloy containers, trays and fixtures. Pratt & Whitney knows no compromise with quality. *(Photo courtesy Aero Digest. Signed by Merrill in Boston).*



U. S. Navy "Air Ports" (Portholes to you)

Made under Navy Specs CR5 No. 46S27a

REMARKABLE DUCTILITY

Note the tiny wire-like "whistlers" on this casting — ductile as wire — that can be twisted, braided and knotted.

Fine clean ductile castings of highest physical properties and good machining qualities in super-stainless steels.

(Heat from which this casting was made pulled 96,000 pounds.)

CHARLES WESLEY, Sr.

GOLF balls dropping on his porch and lawn all day Sunday have become so serious that Bill Fitzpatrick, General Alloys Philadelphia Representative, has taken to spending his Sundays at Atlantic City. Mrs. Fitzpatrick does not want to be a Golf Widow, but with a little urging she would make a good pilot.

YOU never heard any Furnace Salesman say his company was using a *better* alloy than X-ite. If it's not X-ite it's a ten to one bet that it's a common 35-15, costing about 3c per lb. less and certain to give you a year or two less service. Specify General Alloys Castings when you buy furnaces.

DICK MERRILL'S first sight of land, flying back from the Coronation, was coming through a low cloud over Squantum, after passing close over the Yacht Guardian. He made a good landing in a tiny Naval Reserve Field, with radio out of order, a perfect blind flight. Brought safe across the Atlantic by his Pratt & Whitney Wasp Motors, 100% heat-treated in Q-Alloy containers, fixtures and X-ite equipped furnaces, Merrill sets new records. The "99 Club," Women Pilots, gave a hangar party in Boston to swell their scholarship fund for children of Pilots killed in flight. Merrill and his Co-Pilot, Lambie, flew their big ... up from New York, devoted an entire ... ning, including dancing and autographing, just to make the little party a success. Merrill is the only pilot ever making a ... forced landing of a transport ship with loss of life. The Radio Beam was ... and Dick's testimony was irrefutable. ... the Dept. of Commerce took the blame ... this *one*. The other pilots, dead, ...

THE "BILL" FITZPATRICKS

testify. I've ridden on those beams ... they were screwy as hell. The system ... still half-baked, weather reports ... treacherously unreliable.

THIS is written on Chuck O'Connor's ... writer, Barnes Airport, Westfield, Mass., while we wait for the clouds to clear ... hill-tops. This spot looked GOOD last ... When crossing the mountains from Albany above the "soup," we went blind in ... valley — flue for Springfield's smoke ... near the stacks for comfort. After ... the high school ball field, we "sank" ... this port because Chuck, who had gone ... for the night heard us and came back ... steer us in.

GENERAL ALLOYS COMPANY

367-405 W. FIRST ST., BOSTON, MASSACHUSETTS, U. S. A.

PLANTS

BOSTON, MASS.

CHAMPAIGN, ILL.

OFFICES AND REPRESENTATIVES

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OHIO H. G. Chase, Dist. Mgr. 199 W. Main St. Alliance
CLEVELAND Hal W. Reynolds 3346 Superior Ave.
DAYTON A. H. Valentine 1926 So. Malvern Ave.
PHILADELPHIA W. T. Fitzpatrick 400 Morris Bldg.
ST. LOUIS Randolph Wohltman 315 No. Seventh St.
WEST HARTFORD, CONN. 716 Farmington Ave.
MILWAUKEE C. R. Slensby 1412 Bankers Bldg.
BUFFALO 812 Tacoma Ave.
RICHMOND, VA. J. F. Leonard 3414 Noble Ave.
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OLDEST AND LARGEST EXCLUSIVE MANUFACTURER OF HEAT & CORROSION RESISTANT ALLO

REBUILT for $193
RETURNS $2736

Result of Relining This Furnace with

INSULBRIX and INSULBLOX

Hearth Area 3' x 6'

- *Pays for Itself First Month*
- *Earns 13 Times Its Cost Yearly*
- *Handles 1300 lbs. More Metal Daily*
- *Saves 300 Working Hours*

It cost a manufacturer only $193.71 to reline his gas fired furnace with INSULBRIX 2600 and INSULBLOX. This modernization brought his heat treating cost down from 34c to 15c per 100 lbs. of metal. Boosted daily output from 3500 lbs. to 4800 lbs. He now gets 8 heats instead of 7—100 lbs. more per charge—and a one hour shorter working day. In one year the installation pays him back $2736—a net profit of $2542—an investment with a 1300% dividend!

You might get even better results!

Send for Bulletin MP 326

INSULBRIX 2600: service temp. up to 2,600° F. Developed for heat-treating, annealing, and other types of fuel fired and electrically heated furnaces; as well as waste heat boilers, flues; also oil stills, core ovens, baking ovens; etc.—1/17 heat storage capacity of heavy refractories for same heat flow; 1" has insulating value of 5" of fire brick.

Also available: **INSULBRIX 3000** and **INSULBRIX 3000-SUPER.**

INSULBLOX—refractory block insulation used for direct exposure to 2,000° F. or in back of thin furnace linings up to 2,200° F.; hence **INSULBLOX** permit moving insulation 300-500° F. nearer to the fire.

The heat storage capacity of **INSULBLOX** is ordinarily about one-sixtieth that of fire brick for the same heat flow. 1" thickness of **INSULBLOX** is equal in insulating properties to about 9" of fire brick.

QUIGLEY COMPANY, INC.

56 W. 45th Street, New York, N. Y.

Makers of* HYTEMPITE, *"The World's Standard High Temperature Cement"

Distributors with Stocks and Service in Important Industrial Centers throughout the United States, Canada, and in 32 other countries. In Canada, Quigley Company of Canada, Limited, Lachine, P. Q.

Help Yourself

to this

HELPFUL LITERATURE

Heat Treating

A folder by Industrial Heating Equipment Co. explains and illustrates diagrammatically a continuous type heat treating furnace in which temperature can be held to within extremely close limits, and in which the product is always uniformly heated. Bulletin Ga-168.

Free Cutting

Jones & Laughlin Steel Corp. has published in booklet form a paper presented to an Elks chapter meeting on "Free Cutting Steel" by H. W. Graham, general metallurgist. Bulletin Ga-50.

Streamlined

Streamlined is what The Titanium Alloy Mfg. Co. calls a new manganese-titanium steel. It is strong, light and economical and is excellent for railroad side frame castings. Bulletin Ga-90.

Sheet Metal Guide

If you work with sheet metal you will be sure to want this 63-page booklet by United States Steel Corp. It is chock-full of helpful hints and useful practical information on galvanized, black, terne and stainless steel sheet. Bulletin Ga-79.

Optical Aids

Bausch & Lomb's new catalog lists and describes the instruments and accessories that are especially useful in the metal working industries, such as the toolmakers' microscope, the wide field binocular, the shop microscope, and the Brinell microscope. Bulletin Ga-35.

Seamless Tube

Excellent illustrations are combined with clearly written text to portray the wide variety of seamless flexible metal tubing made by American Metal Hose Branch of the American Brass Co. Bulletin Ga-89.

Sub-Zero

Data on low temperature properties of nickel alloy steels are assembled by International Nickel Co. for the convenience of those interested in constructional steels to withstand sub-zero temperatures. Bulletin Ga-45.

Safety in Oxwelding

A revised edition of "Precautions and Safe Practices" in the care and handling of oxy-acetylene equipment has been prepared by The Linde Air Products Co. This booklet is regarded as a standard reference on this phase of safety in industry, and this latest edition contains some new suggestions required by advances in the oxy-acetylene process. Bulletin Mx-63.

Heating Units

Here, in one small book, are the answers to the hundreds of small heating problems that arise daily in industrial plants. General Electric Co. catalogs a wide enough variety of heating units and devices to satisfy almost any conceivable heating requirement. Bulletin Ga-60.

Air Heaters

The type of gas-fired air heater described in this folder is applicable to japanning, core and mold baking, enamel finishing, and many other industrial baking or drying processes at temperatures up to 550° F. General Combustion Corp. Bulletin Ga-166.

Radiant Tubes

A brief story of the Surface Combustion horizontal gas-fired radiant tube heating element is accompanied by photographs and pertinent data for a hardening furnace and for a drawing, annealing and normalizing furnace installation. Bulletin Ga-51.

New Joining Process

Metal parts are joined cheaply, neatly and strongly by Electric Furnace Co.'s new, inexpensive non-oxidizing furnace atmosphere and their new, continuous brazing, coppering and soldering furnaces. Full details are given in Bulletin Ar-30.

Hump Hardening

All three vital factors in correct hardening are completely controlled by the new Vapocarb Hump method of hardening, which is well described in a Leeds & Northrup bulletin. The three factors are: Quench point, rate of heating, and furnace atmosphere. Complete details are given in Bulletin No-46.

Chapmanizing

Chapmanizing, the new method of surface hardening steel with nitrogen, is described in a very attractive booklet of Chapman Valve Mfg. Co. Information is given out on the method itself and on its metallurgical advantages. Bulletin Ob-80.

Thermit Welding

Metal & Thermit Corp. offers a new booklet showing all the possibilities of Thermit welding, explaining the action, and telling in detail how representative Thermit welds can best be made. Well illustrated and clearly written. Bulletin Ar-64.

Pyrometer Accuracy

A thought-provoking folder of Hoskins Mfg. Company explains how the use of Chromel-Alumel for pyrometer lead-wires makes it possible to take full advantage of modern pyrometric instruments. Bulletin Ob-24.

Vanadium Facts

Revived after nearly 20 years is the house organ of Vanadium Corp. of America, "Vanadium Facts." This paper shows considerable thought and care in its preparation and contains valuable and interesting information on vanadium steels. Bulletin Ox-27.

High Speed Furnace

American Gas Furnace Co.'s improved high speed furnace provides atmosphere control, combustion control, speed, economy, and clean, hard work. Clear and complete description is given in Bulletin Ny-11.

Vertical Carburizer

The Hevi Duty electric vertical retort carburizer is particularly applicable to intricate parts and selective carburization, where distortion must be held to a minimum. It is described in Bulletin My-44.

Easy Flow Brazing

Handy & Harman's Easy-Flo Brazing Alloy, a recent development, is recommended for joining stainless steel and iron, Monel metal, Inconel, Everdur and other ferrous and non-ferrous metals. Briefly described in Bulletin Ny-126.

Electric Salt Baths

Literature is available from Bellis Heat Treating Co. describing electrically heated bath furnaces which are economical to operate and have a wide range of applications in hardening, annealing, and heat treatment of high speed steel, stainless steel, nickel, aluminum, copper and bronze, etc. Bulletin Ny-48.

Tempering Furnace

Technical details and operating data on Lindberg Steel Treating Co.'s new Cyclone electric tempering furnace, which has shown a remarkable performance record in steel treating operations, are given in Bulletin Fx-66.

Metal Surfaces

A manual giving in detail methods for the application of sodium cyanide solutions in the preparation of metal surfaces is announced by the R. & H. Chemicals Department, E. I. du Pont de Nemours & Co. Bulletin Ba-29.

Blast Cleaning

So many changes have taken place in blast cleaning and dust collecting equipment in the past three years that Pangborn Corporation's "quick reference" catalog of condensed information will be invaluable to all those interested in this subject. Bulletin Jy-68.

Chain

Interesting information on chain and belt conveyors for use at high temperature may be had by sending for a new illustrated bulletin by Michigan Steel Casting Co. Bulletin Dy-84.

Heat Treating Manual

A folder of Chicago Flexible Shaft Co. contains conveniently arranged information on heat treating equipment for schools, laboratories and shops, and also illustrates the several types of Stewart industrial furnaces. Bulletin Ar-49.

Refractory Blocks

Light-weight, low heat storage insulating refractory blocks known as "Insulblox" for reducing heat storage and radiation losses at operating temperatures up to 2200° F. are described in a folder by Quigley Co. Bulletin Ea-139.

Limitrol

An automatic shut-off instrument designed for use with or without controllers of any type to protect furnaces and furnace loads from excessive heating due to a weakness in control or failure in switching apparatus is described by Wheelco Instrument Co. Bulletin Ea-110.

Induction Furnaces

A publication of Ajax Electrothermic Corp. tells of the development, operating principles, applications, and advantages of commercial Ajax-Northrup coreless induction furnaces energized by motor generator sets. Also information regarding standard sizes of motor generator sets and furnaces. Bulletin Jr-41.

Alcoa Notes

"Alcoa Random Notes" is the intriguing title of a little monthly paper got out by Aluminum Co. of America. A request for this bulletin will bring you a copy of the latest issue. Bulletin Ca-54.

Corrugated Ingots

The Gathmann Engineering Co. has published a new booklet called "Gathmann Ingot Molds — Their Purpose and Design." It illustrates various corrugated ingot contours designed to produce defect-free surface in steel ingots. Bulletin Ay-13.

Foundry Metallograph

Today's engineering cast irons are structure-controlled in the foundry. The E. Leitz simplified micrometallograph MM-2 is particularly adapted to foundry applications. Bulletin Fy-47.

Some of the Best Thinking

in the metal industries is at your disposal in the literature described here. One booklet may hold the key to your current problem. Help yourself to this helpful literature. It's free. You incur no obligation when you return the coupon.

Moly Matrix

Climax Molybdenum Co.'s little monthly newspaper contains many interesting and informative articles. Get the latest issue—Bulletin Ax-4.

Hy-Speed Case

A striking and interesting new booklet on Hy-Speed Case has just been published by the A. F. Holden Co. Typical applications and results are cited. Bulletin Fa-55.

Welding Instruction

A complete training school in arc welding is maintained by the Lincoln Electric Co. in Cleveland. A complete description of the course including duration, registration and fees is given in an illustrated booklet. Bulletin Fa-10.

Air Weight Control

An illustrated booklet of sure-fire interest to the foundry trade has been issued by The Foxboro Co., explaining in detail the advantages of the "air weight controller" which is in use at many of America's leading foundries, named in the publication. Bulletin Ea-21.

Copper Bulletin

A new clearing house for news of developments in brass, bronze, and copper, the "Copper Alloy Bulletin," issued by the Bridgeport Brass Co., made its appearance with the March issue. It is edited for the technical and engineering audience. Bulletin Da-163.

Turbo-Compressors

Spencer Turbine Co. has turbo-compressors in all sizes and types for oil and gas-fired furnaces, ovens and foundry cupolas. Special types for special purposes such as gas-tight and corrosion resisting applications are also described in Bulletin Da-70.

Stainless Data Book

All users of stainless and heat resisting alloys should find invaluable the information contained in a booklet published by Maurath, Inc. giving complete analyses of the alloys produced by the different manufacturers, along with the proper electrodes for welding each of them. Bulletin Jy-125.

Flame Hardening

The rapid development in recent years of the process of hardening with the oxy-acetylene flame well warrants the publication of this handsomely printed booklet which contains a multitude of excellent photographs of the applications of the process and of the equipment. Air Reduction Sales Co. Bulletin Ga-69.

Laboratory Service

A new edition of "The Metal Analyst" tells about an organization established by Adolph I. Buehler specializing in the installation of metallurgical laboratories. The complete line of laboratory equipment marketed by Buehler is also catalogued. Bulletin Dy-135.

Heat Resisting Alloys

Authoritative information on alloy castings, especially the chromium-nickel and straight chromium alloys manufactured by General Alloys Co. to resist corrosion and high temperatures, is contained in Bulletin D-17.

Stress-Strain Recorder

The many applications of the Baldwin-Southwark stress-strain recorder, its unique advantages, and the many ways it can give unusual service will be extremely interesting to all who have to do with testing methods and equipment. Bulletin Ba-67.

Nickel-Copper Steels

Exceptional resistance to corrosion and abrasion, increased tensile strength, and higher ductility are the qualities claimed for Youngstown Sheet & Tube Co.'s new series of Yoloy steels. A summary of properties and notes on their characteristics are contained in Bulletin Ox-93.

Photo-Electric Cells

If you are not familiar with the wide field of applications for photo-electric cells and apparatus, send for this very interesting and complete booklet by Pfaltz & Bauer, Inc. covering the original apparatus developed by Dr. Bruno Lange. Bulletin Ca-142.

Testing Machines

An extremely handsome, spiral-bound, segregated catalog tells all about the various hydraulic and screw power testing machines made by Tinius Olsen Testing Machine Co. Bulletin Oy-147.

Diamond Wheels

A striking presentation is made by the Carborundum Co. in a 52-page booklet on diamond wheels. Detailed technical information is contained and a price list attached. Bulletin Ca-57.

Port Valves

Diagrams and descriptive matter show the operation of adjustable port valves made by North American Mfg. Co. that are particularly suitable for mediums whose rate of flow is not constant. Bulletin Oy-138.

Newer Tool Steels

Vulcan Crucible Steel Co. has a complete and attractive catalog listing their full line of tool steels including many special types to meet the modern trends in industry. Bulletin Jy-127.

Ni-Cr Castings

Compositions, properties, and uses of the high nickel-chromium castings made by The Electro Alloys Co. for heat, corrosion and abrasion resistance are concisely stated in a handy illustrated booklet. Bulletin Fx-32.

Dust Collector

How the Schneible multi-wash dust and fume collector operates and what it does are clearly shown in a catalog giving details on existing installations. Published by Claude B. Schneible Co. Bulletin Ca-161.

Rustproofing

How the Detrex method of solvent degreasing provides the advantages of speed, economy, and satisfactory cleaning before all kinds of rust-proofing and finishing operations is pointed out in a leaflet by Detroit Rex Products Co. Bulletin Dy-111.

Thermometers

A complete catalog and price list with excellent illustrations covers all manner of thermometers and hydrometers, made by C. J. Tagliabue Mfg. Co. Bulletin Fa-62.

Spectrum Analysis

The elements of both qualitative and quantitative spectrum analysis are contained in a handy booklet by Carl Zeiss, Inc. A price list covering all equipment is included. Bulletin Da-28.

Alloy Castings

Michiana Products Corp. has published a new book describing Michiana corrosion resistant and stainless steel alloys. Generously illustrated, it suggests many savings for the use of these alloys. Bulletin Oy-81.

Oxidation

Designers confronted with oxidation problems connected with cracking coils, polymerization plants, superheaters, high pressure steam plants, air heating equipment and recuperators will welcome a folder by Timken Roller Bearing Co. containing data on oxidation at 1000, 1250 and 1500° F. Bulletin Ea-71.

Rockwell Tester

A revised and completely up-to-date catalog on the well-known Rockwell hardness tester is well illustrated and contains 24 pages. Published by Wilson Mechanical Instrument Co., Inc. Bulletin Ca-22.

Water Supply

Modern design, sturdy construction, compact size, and light weight are stressed as features of the water systems and pumps built by Roots-Connersville Blower Corp. Described in Bulletin Ga-131.

Protection Tubes

The advantages of a die cast over a sand cast pyrometer protection tube are described and illustrated by Driver-Harris Co. Stock sizes of Nichrome protection tubes are listed. Bulletin Ga-19.

Grinding Lubrication

A handy outline for the selection of grinding wheels is one of the useful features of a booklet full of facts about grinding solutions. D. A. Stuart & Co. Bulletin My-118.

Salt Bath

"Heating from the inside out" is what makes the Ajax-Hultgren salt bath furnace practical. Ajax Electric Co. explains this new operating principle in an interesting folder. Bulletin Oy-43.

Testing with Monotron

Shore Instrument & Mfg. Co. offers a new bulletin on Monotron hardness testing machines which function quickly and accurately under all conditions of practice. Bulletin Je-33.

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NATURAL GAS—
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A natural gas furnace in the forge shop of a major Houston manufacturer of oil well tools.

The availability of natural gas in unlimited quantities has been, is, and will be a decisive factor in the location of new industry on the Texas Coast. For natural gas is a Texas resource upon which rests the industrial utilization of numerous others.

Natural gas is the most efficient of fuels. Its use eliminates the necessity of investing in expensive handling machinery and storage space. It is delivered to the consumer in a pipe and a valve controls its flow to the furnace; it is cleaner to handle and burn than any other fuel*; its combustion is more easily controlled by automatic control devices; and its use materially reduces the cost of furnace maintenance.

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* Visitors to the Texas Coast Country invariably comment on the smokeless cleanliness of its industrial centers.

TANTALUM STEELS

(Continued from page 56)

Plain tantalum steels show no marked resistance to corrosion under an intermittent salt spray test or when submitted to ordinary outdoor exposure.

Small amounts of tantalum have little effect on the properties of low-manganese nickel steel. Even with further additions the action is mild; with 1.75% of tantalum the properties are only slightly better than may be obtained by the addition of 0.50% of manganese. Tantalum does not confer air hardening properties on the nickel steels. It reduces the maximum hardness attainable by quenching, and has only a slight effect in increasing the hardness when cooled at slower rates, but it reduces the fall of hardness which occurs on tempering. It also induces susceptibility to temper brittleness in nickel steel to an appreciable extent.

Experiments on the effect of tantalum on the nitriding properties of steel showed that while tantalum alone has the effect of considerably increasing the depth of penetration of nitride above that given by the commonly used nitriding steels, an extremely high hardness is not attained. Alloys containing a small addition of aluminum together with tantalum or niobium gave, however, an increase in hardness up to above 1000 Vickers with no appreciable decrease in depth of penetration.

Tantalum carbide is known to be very hard and is being used commercially in sintered carbide tools for cutting hard and tough materials. Hence it appeared possible that the cutting properties of a steel might be improved by the incorporation of tantalum carbide in this way. Experimental steels were therefore made, utilizing molten white pig iron as the basis metal, by progressively adding ferrotantalum. Tantalum carbide is formed as sharply angular crystallites. At 25% of tantalum the alloy consists substantially of tantalum carbide particles in a ground-mass of ferrite. Such an alloy may take a sharp and hard edge, but is useless for cutting under pressure, owing to the poor qualities of the ferrite bond. The ground-mass may, however, be strengthened in various ways, and experimental steels have been made which show remarkably good cutting properties when turning fairly hard steel.

Working in the opposite direction, if carbon is added to molten ferrotantalum the carbide is formed and the alloy becomes "pasty." The completely carburized alloy is brittle when solid and is readily crushed to a fine powder. Iron and impurities can be removed by 50% hydrochloric acid, leaving insoluble tantalum carbide. This method for the economical production of carbide has been employed on the laboratory scale with success, and tests of the carbide in the form of sintered tools are being made.

EDITORIAL NOTES . . .

Compounding of Metal Powders

CHARLES HARDY, well known to many Chapters as an enthusiast about metal powders and powder metallurgy, recently told the Detroit Chapter something about applications other than for small bearings and bushings with which those in the automotive industry are quite familiar. These have to do first with combinations of metal of quite different melting points, such as copper with 50% lead or, more striking, aluminum with 5% tantalum, and second with metal and non-metal combinations like copper and graphite, or nickel and cement, or carbides and metal binder.

Interesting new applications are for commutator segments, where to the electrical conductivity of pure copper are added elements for wear resistance; for permanent magnets made of metal combinations like cobalt, nickel, aluminum and iron, which, when cast, are undesirably coarse grained, hard and brittle; for welding rods where flux particles are incorporated with the proper metallic ones; for clutch facings with enough porosity to give metal of low apparent thermal expansion and consequent resistance to heat checking; and even for easily oxidized powders that when moistened generate enough heat in a pad to keep your feet warm in cold weather or to curl your wife's hair in a beauty parlor.

Even though the applications of metal powders are so various, Mr. Hardy's estimate of 20 million pounds of powdered metal, made by grinding, electrodeposition or chemical reduction, must include that used for paint and bronze powders — and hence not strictly metallurgical.

Welding Rods and Electrodes

ORCHIDS are due to Norman L. Mochel, for his patient and successful efforts as chairman of an A.S.T.M. committee which prepared a tentative specification for iron and steel filler metal (arc-welding electrodes and gas-welding rods). There are so many special analyses of welding rods promoted for this, that and the other purpose (to say nothing of competitive items which are often not at all special), that it is an achievement of no mean order to secure agreement even in one branch of the industry. Add to this the fundamentally different conditions at the focus of an oxy-acetylene flame and an electric arc, and it might seem useless even to attempt to harmonize the requirements of these two processes.

Doubtless the document contains so many compromises that it is not wholly satisfactory to anyone concerned. For this reason a number of supplementary paragraphs have been added, to take care of additional requirements should they be regarded as important by the user of the specification.

If, now, the various manufacturing and purchasing agencies will make a sincere effort to use this new specification, it can be rapidly perfected. Ample precedent indicates that a wide use of such a document, in place of a multitude of individualized specifications, will increase the uniformity and quality of a material and lower its cost.

Synthesizing an Alloy to Order

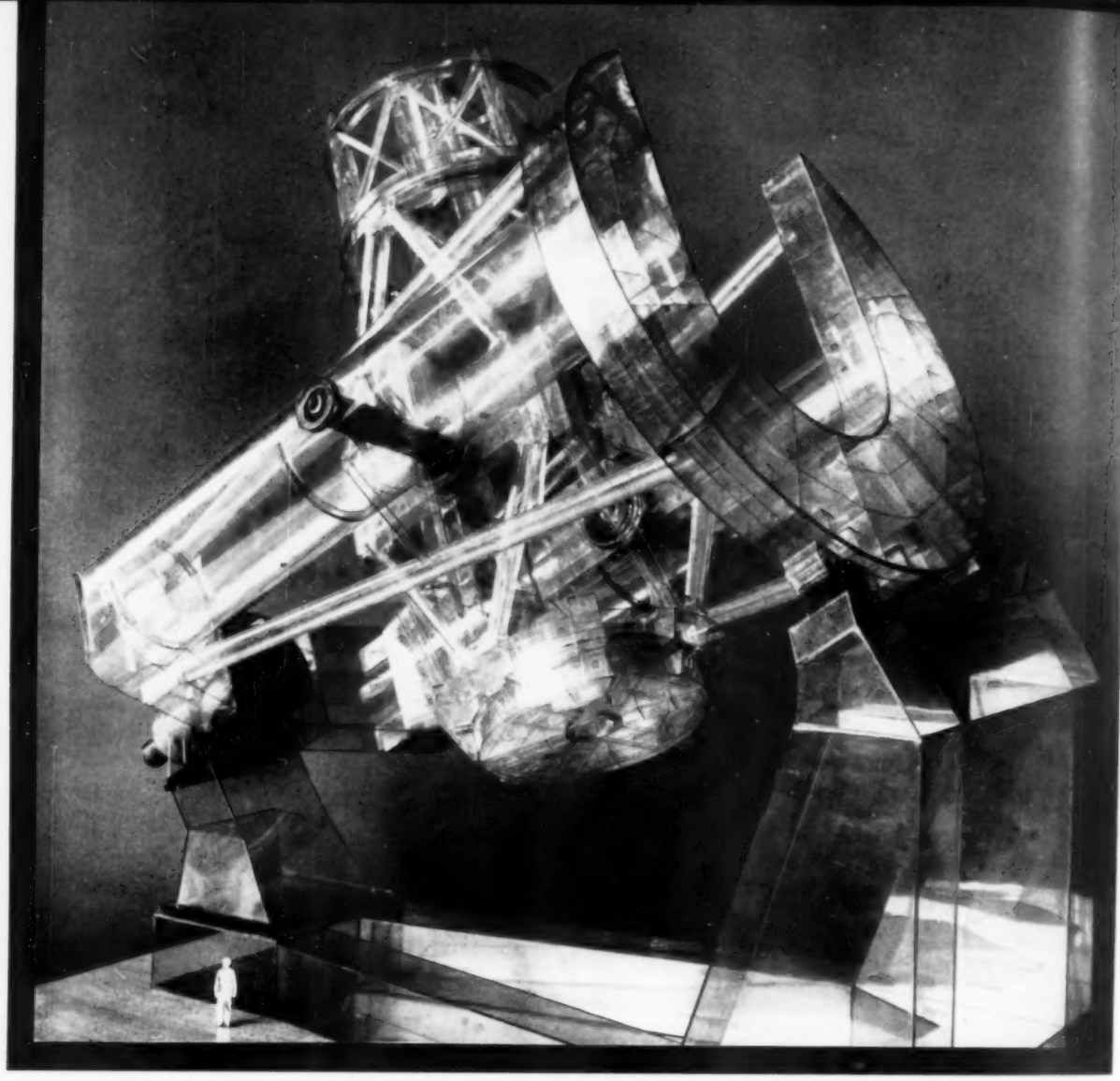
SOUND RECORDING has usually been done by Edison's method of cutting a variable track in wax or soft metal. However, the high frequency current coming from the microphone may as well be used to impress a permanent magnetic pattern within a thin piece of metallic tape. Reproduction of the sound in either case is done by reversing the process.

Use of magnetic tape, suggested almost 40 years ago, has been utilized in telephonic systems where some delay in transmission is desirable. More recently it has been perfected by Bell Telephone Laboratories for places where a record of speech needs to be kept but for a short time, and a battery of machines is used by the New York Times to record all messages telephoned in by reporters. It is only necessary to subject the tape to a strong magnetic field in order to obliterate the record and prepare it for re-use.

Success has involved the production of tape of high dimensional accuracy and microstructural uniformity, magnetically hard but mechanically soft, and reasonably cheap — certainly a notable job of synthesizing an alloy to given specifications!

Weld Structure — a Correction

TURN to page 66 of the July issue and insert the words "the zone below" before the words "this columnar edge" in the 18th line of the right-hand column in H. S. Blumberg's note about sound welds in very thick plate. Microscopically there IS a great deal of difference between the columnar surface zone of a massive weld and the finely crystalline metal deeper seated, as the columnar structure is considerably larger in grain microscopically and is of the feather type of structure due to the high temperature from which it was cast in the welding process without subsequent treatment. Apologies are due to Mr. Blumberg for this misinterpretation of one of his letters.



Celluloid Model, 1/32 Size, Was Very Useful in Studying Elastic Movements When Loaded in Various Ways

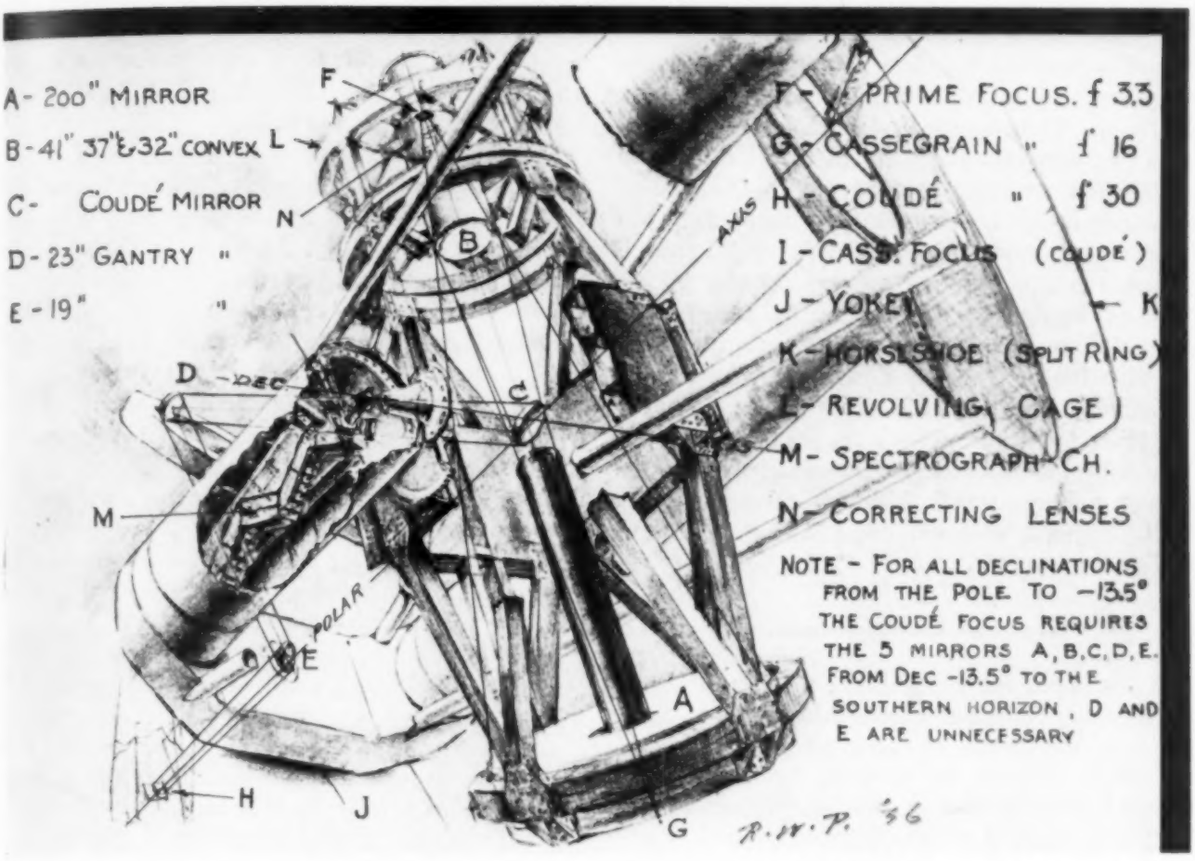
200-IN. TELESCOPE, WORLD'S LARGEST, HAS MOUNTING OF WELDED STEEL

By G. H. Froebel
Executive Division
Westinghouse Electric & Mfg. Co.
South Philadelphia Works

ONE OUNCE of aluminum and photographic emulsion constitute the essential optical surfaces of the 200-in. telescope illustrated on the front cover of this issue. To permit these surfaces to function properly, however, some 35,000 lb. of glass and about 1,000,000 lb. of steel are required!

The steel forms the mounting of the telescope, and as shown by a 1/32 scale celluloid model above, consists of two parts — a latticed "tube" and a massive cradle or yoke which carries the tube. Then, of course, there are the bearings and the foundation.

The tube of any telescope serves as a supporting structure for the principal optical elements, holding


A- 200" MIRROR
B- 41" 37" & 32" CONVEX
C- COUDÉ MIRROR
D- 23" GANTRY "
E- 19" "
F- PRIME FOCUS. f 3.3
G- CASSEGRAIN " f 16
H- COUDÉ " f 30
I- CASS. FOCUS (COUDÉ)
J- YOKE
K- HORSESHOE (SPLIT RING)
L- REVOLVING CAGE
M- SPECTROGRAPH CH.
N- CORRECTING LENSES
NOTE - FOR ALL DECLINATIONS FROM THE POLE TO -13.5° THE COUDÉ FOCUS REQUIRES THE 5 MIRRORS A, B, C, D, E. FROM DEC -13.5° TO THE SOUTHERN HORIZON, D AND E ARE UNNECESSARY
AXIS
POLAR
DEC
R. W. P. '36

Crayon Drawing by R. W. Porter Shows the Principal Optical Arrangements. For convenient working on a swiveled platform from the lower end of the tube, the mirror B catches the starlight reflected by the 200-in. concave mirror A, and sends it back through a central hole in A to the "Cassegrain focus." For spectroscopic work in a constant temperature room below the foundation, other mirrors C, D, and E bring the light to the so-called Coudé focus. For maximum light gathering power from the faintest stars, all mirrors are removed and photographic plate is placed at prime focus F

these elements in a fixed relationship in space no matter where the telescope may be pointed.

Since this record-breaking 200-in. telescope is a reflecting telescope, its tube does not correspond in any respect to the kind of tube we are used to associating with small sized telescopes or spy glasses. First of all it is not a tube but an open structural framework. Instead of carrying a lens at its *upper* end, it carries a concave mirror, 200 in. in diameter, at its *lower* end. Instead of looking at the object from the bottom end, an observer stationed at the top end turns his back on the object and looks downward toward the mirror. All observations, however, are recorded photographically.

The tube can rotate about two trunnions and these are supported in the yoke. Its range of rotation is from the southern horizon to the north pole. The axis through the trunnions is known as the declination axis. (See Mr. Porter's sketch above for the principal elements.)

This massive yoke which supports the tube can also turn about an axis, at once perpendicular to the declination axis and pointing directly at the north star (celestial pole, to be exact). This axis is called the polar axis of the telescope. The yoke can rotate far enough to either side of the meridian plane so that the telescope can be directed toward any point above the horizon.

Starting his observations, the astronomer will first "set" the instrument to bring the celestial object he wishes to study in his field. This will generally require two motions — one about the polar axis (the yoke moves, carrying the tube with it), and one about the declination axis (the tube moves with respect to the yoke). Since it is important on nights of good visibility to have as much time as possible available for observations, the instrument will have a "fast" setting speed of ⅛ r.p.m., which means that it will take 4 min. to move from eastern horizon to western horizon.

After the object in the sky has been located, the telescope has to follow it accurately, without lag or vibration, while a photographic exposure is made. That means that the telescope motion has to counteract the rotation of the earth and rotate from east to west at "driving" speed of one revolution a day about the polar axis. In addition it is necessary to make certain small compensations continuously, as for the refraction of the light rays by the earth's atmosphere.

Motions about the polar axis and the declination axis are performed by means of wormwheels cut with great precision. For the rotation about the polar axis, there will be two gears mounted on a tubular extension of the lower yoke; one of these will serve for the setting speed, and the other will be used for following the star.

General Considerations

So much for the general principles of the telescope. Now for a little history and finally some of the details of construction.

This project dates back to 1918, when immediately following the completion of the 100-in. telescope at Mt. Wilson, George Ellery Hale began planning for a much larger instrument. The necessary grant of money was received from the Rockefeller Foundation in 1928 and the entire undertaking is expected to be completed by 1940.

The advantages of the 200-in. telescope over those now available are many and of great significance. It will enable astronomers to see 1,000,000,000 light years, twice as far into space as heretofore possible. It therefore will enlarge the volume of the known universe by eight times. It will permit more accurate observations within the space now visible due to the fact that the 200-in. mirror will collect four times as much light as the best instrument now in existence. Under ideal conditions, it will bring the moon's surface apparently within 24 miles of the earth!

A size of 200 in. was selected on the basis that it would hardly be prudent to do more than double the diameter of the greatest existing mirror. There is also a feeling that increasing aperture diameters will not always lead to increasing usefulness. Furthermore, the cost of the project increases as the cube of the objective aperture — and Mt. Wilson had cost between $500,000 and $1,000,000. After some ten years of planning and discussion Dr. Hale persuaded the Rockefeller Foundation to provide $6,000,000 to build and house it; California Institute of Technology, under the leadership of R. A. Millikan, undertook to operate it.

The entire choice of type and design of the mounting for the 200-in. size stemmed from the size and focal length of the mirror and the demands of visibility. As the scale of a telescope becomes larger, the two factors which must be guarded against — excessive angular and linear distortions — become worse. The angular deflections of the tube caused by the weight of the tube and mounting increase in proportion to the size, and the natural frequencies (a measure of the rigidity and steadiness of the mounting) decrease inversely proportional to the size. Generally speaking, it was required that the mounting be as stiff and as light as possible. This pointed to the use of thin-walled, box type, welded structures.

There is nothing of an experimental nature in the adoption of welded construction for the various members of such a project. Other structures, of comparable size and complexity, and of like value and importance, have been produced successfully by this method.

It must be understood that the various member parts are prepared by machining for bolting together at the site, Mt. Palomar, in Southern California. "Welded construction" in this instance does not mean that member parts are to be so joined on location. It is true that in many large engineering structures, member parts have been and are being joined by welding on location, but the intended service is such as to tolerate distortions that would take place during welding or during the useful life of the apparatus, or such that the presence of variable and unknown degrees of internal stress are of little concern.

Materials — One is naturally interested in the materials that are to be used, and that must submit to welding. Again one encounters an erroneous impression, that a telescope must be constructed largely of special alloys that have low expansivity. While it is true that some materials of this type are used in connection with the optical parts, most of the material used for the tube and mounting is quite ordinary mild carbon steel of standard commercial grades that are being welded day in and day out. This is an important practical consideration.

In all cases, plates, bars and structural shapes have been rolled by one supplier from selected heats, to give the greatest possible uni-

formity of composition. Steel plates less than 1½ in. thick were made of the usual flange quality, similar to that covered by A.S.T.M. specification A70-36. All such steel for the tube was made from a single heat, specially melted for the purpose. Plates 1½ in. thick and greater were rolled from silicon killed steel poured into hot top ingots, to guarantee soundness of section. This steel is similar to Grade A in A.S.T.M. specification A150-36. Two carbon-molybdenum steel forgings are used in building up the declination bearing housings.

Welding Electrodes — While oxy-acetylene cutting has been widely used in shaping the individual pieces, arc welding only has been employed in joining them; in all cases, heavily coated electrodes of the mineral coating or slag producing type were used.

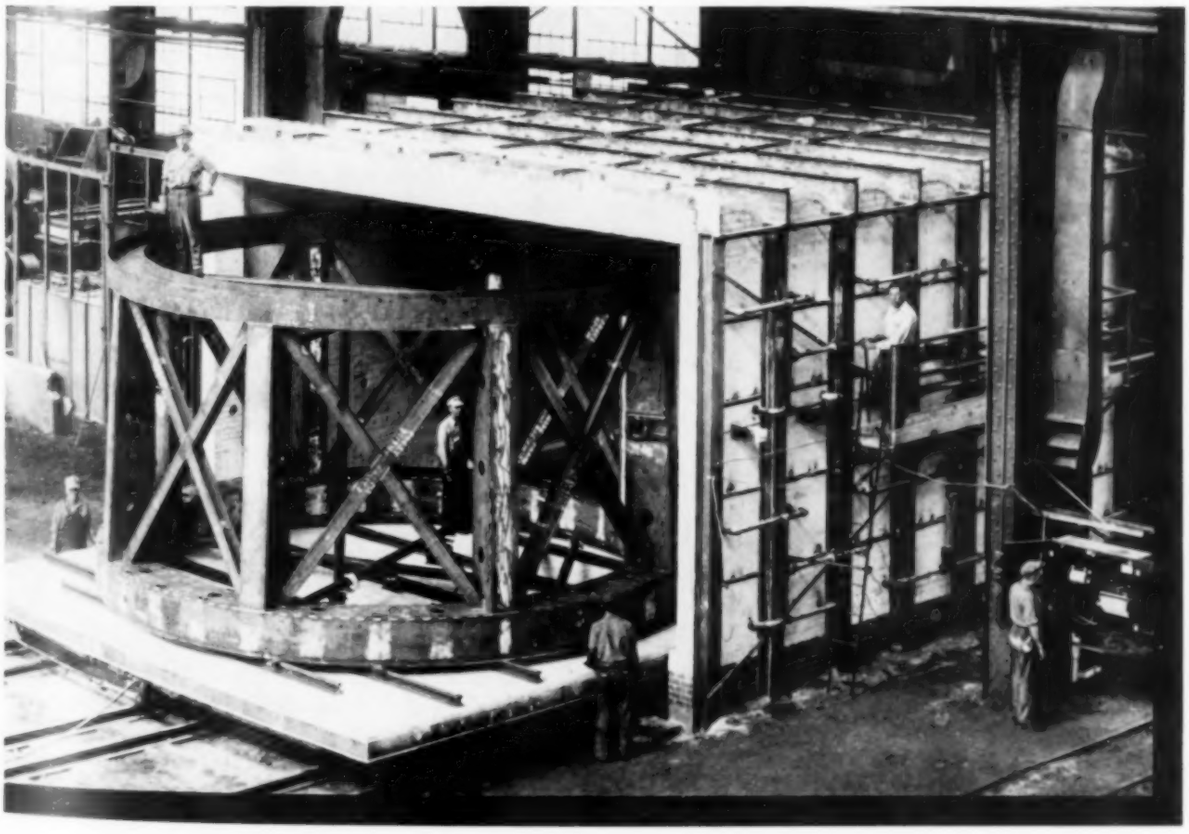
It is well recognized today that electrodes can be devised that will best meet some given condition of deposition. Full advantage of this has been taken and three kinds of electrodes, as regards position of deposition, have been used. One was used for all downhand butt welds, another for all downhand or horizontal fillet welds, and yet another for welds that of necessity had to be made in a vertical position. Overhead welding has been avoided.

Operators — In our regular work at South Philadelphia, we are called upon to qualify our welders to a variety of codes and specifications. Of necessity, we have developed all-inclusive codes and process specifications of our own, so that qualification under our own more extensive requirements qualifies an operator to perform under any of the above codes and specifications.

Welding — Nearly all welding has been manual welding. Exceptions are the two declination bearing housings, which used automatic welding for the longitudinal and external circumferential welds.

In welding such large parts as these, careful study and planning of the work are very important. There is a best place to start, and a best sequence of operations. One does not have an opportunity to practice with a first few and thus develop a final technique. Large leveled floor plates are also of absolute necessity. The need

A 26x26-Ft. Annealing Furnace, 20 Ft. High Above Car Bottom, Was Built to Stress-Relieve the Largest Welded Piece. These units will be deck loads on steamships from Philadelphia to San Diego

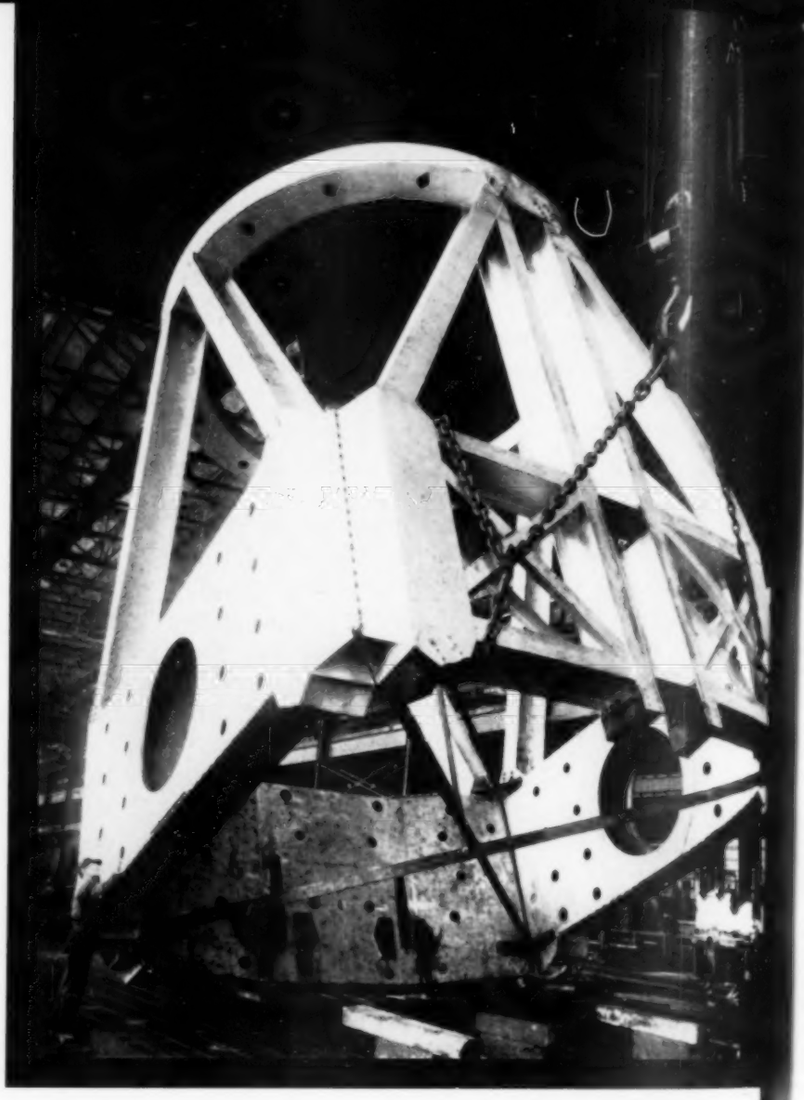


for ample space, for proper supporting and for firm foundation, will be obvious.

Annealing or Stress-Relieving — All of the telescope parts have been carefully annealed to relieve internal stresses. In order to do this most thoroughly we have used a double annealing cycle, heating to 1150 to 1200° F., holding for a period of 3 hr. for the first 1 in. of thickness plus an additional hour for each additional 1 in. thickness or fraction thereof, followed by a slow cooling in the furnace until the temperature has fallen below 600° F., and then repeating this cycle in its entirety and cooling below 300° F. before the furnace doors are opened.

An engraving on page 135 shows the prime focus cage being moved into the furnace, especially constructed to anneal the telescope parts. A special type of gas burner was used that gives a quieter acting flame and avoids long, hot flames impinging upon the work. Burners are also located in the car bottom at the front of the furnace to avoid a cold spot there. The door or front cover is made in sections that hang from the roof and tightly seal the furnace. Baffles of heat insulating bricks were built up at four points where the circumference of the cage came too close to the walls and the burners. Thermocouples are in actual contact with the work and continuous autographic records are made from four thermocouple locations throughout all annealings.

The following summarizes the treatment of the prime focus cage, as an example: 12 hr. heating to 1160° F.; 6 hr. holding at 1150 to 1160° F.; 11 hr. cooling to 600° F.; 10 hr. reheating to 1150° F.; 6½ hr. holding at 1150 to 1160° F.; 42 hr. cooling to 125° F.



Cranes Are Here Tilting a Portion of the Main Tube; It Consists of Several Welded Subassemblies, Bolted Together

Accuracy of Work

One is naturally interested in the results of the welding: How closely were the parts held to size throughout welding and annealing? Four indications will be cited.

1. When the prime focus cage was placed on the boring mill to face the lower ring, the departure of the ring from roundness was not greater than $\frac{1}{16}$ in.

2. When the top ring of the tube was placed on the mill to face the upper end, which takes the prime focus cage, the departure from roundness was of the order of $\frac{3}{32}$ in.

3. Note, in the photograph of the partially assembled tube on this page, the bolted joints at the ends of the panels with large holes for trunnions. These mating flanges were machined on faying surfaces but not on the exposed edges, yet at no place in four such joints was there more than $\frac{3}{16}$ in. difference; in general, the joints were much closer.

4. Referring further to the same photograph, when the top ring was lowered into place the four gussets that bolt to the "A" frames were found to be accurate as to position within approximately $\frac{1}{16}$ in.

There is also the problem of over-all accu-

racy. It would be natural to suppose that extremely small tolerances would be demanded. However, nothing beyond the usual accuracy of Westinghouse practice is called for in building the telescope mounting. All final operating adjustments will be made by adjustable mating parts to be made at California Institute of Technology. The closest accuracy called for on the larger parts is in the alignment of the declination axis of the tube and the plane of the diaphragm cage base. The declination axis must be parallel to this plane to within one minute of arc. This calls for measuring at least two lengths of about 26 ft. to within 0.077 in. Since means exist to measure these distances to within 0.001 in., no hardship is imposed.

Aligning the tube, which will weigh 150,000 lb., will be no more difficult than a job of lining up a large turbine. Its size, however, 22 ft. in diameter and 50 ft. long, would tax the space limitations of most shops.

Main Bearings a Problem

The prerequisites of bearing design for an instrument of this type are: *(a)* They must determine accurately the position of the instrument, and *(b)* their operation must be as smooth and frictionless as possible.

Three types were considered:

1. Roller bearings alone. These would require a hardened roller path on the outer rim of the horseshoe, which is 46 ft. in diameter. It appeared to be rather too difficult to mount the rollers so that each one would take an equal load, and to provide proper alignment in all directions.

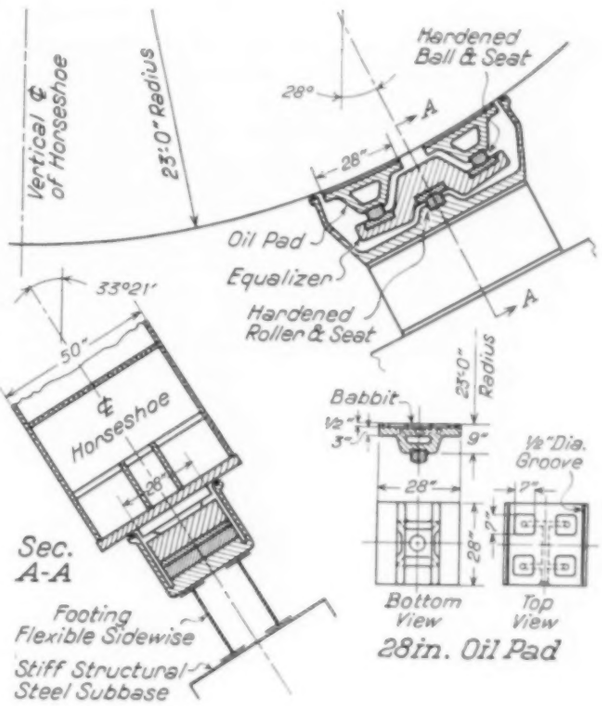
2. Mercury flotation in conjunction with roller bearings (used successfully on the 100-in. telescope on Mount Wilson). Since the 200-in. telescope has a horseshoe-shaped yoke, only a small segment of this horseshoe could be under mercury; consequently, the colossal size of the drum to be attached to the horseshoe made this method seem entirely impractical.

3. Oil pads. This design, based on a principle well known in vertical water wheel bearings and used successfully for more than 15 years in Westinghouse balancing machines, had the advantage of having very little friction (in this case about 1/600 of that of roller bearings) and of being by far the least expensive.

After a thorough analysis of the above, the oil pad design was selected. Its nature is shown in the accompanying line drawing.

This type of bearing depends on a thin film of oil (0.003 in. thick) maintained by feeding the oil into recesses in the pad at pressures of about 300 psi. The only frictional forces to be met are the very small shearing forces created within the oil film itself. Since the velocities are so small (driving speed being one revolution per day), the power required to drive the yoke at one revolution per day is calculated to be 1/165,000 hp.!

Acting against the horseshoe rim there will be two 28-in. square pads on each side of the vertical centerline. Each pad will carry about 150,000 lb., and is mounted on a hardened ball and seat so as to adjust itself to the horseshoe



Each of Four 28-In. Square Oil Pads Under Horseshoe Yoke Floats About 75 Tons of Weight in What Is Almost a Frictionless Bearing

surface. Pads in each pair are balanced against each other by an equalizing member with a hardened roller and seat.

While the north end of the yoke is thus virtually supported at two points along the horseshoe rim, the third point of support is at the south bearing. There again the principle of viscous oil flow will be applied in a large spherical oil bearing, which will carry about 580,000 lb. thrust load and 350,000 lb. lateral load.

FACTORS RELATING THE IMPACT STRENGTH OF METALS WITH THEIR SERVICE

An informal report
by The Editor

PRECEDENT was violated by American Society for Testing Materials last month in holding its fortieth annual meeting (and an exhibit of testing apparatus and related equipment) in New York City. The palatial Waldorf-Astoria was selected, and so those who attended were able to enjoy, for a price, the latest achievements of the air-conditioning and electric lighting experts.

At times, the meetings of this Society have a curious air of finality — statements seem to be made as the last word. Perhaps this is inseparable from the presentation of *standards* — things whose discussion has usually been exhausted in committee. The highlight of this meeting, therefore, was an informal interchange of opinion about impact testing, held under the direction of Prof. M. F. Sayre of Union College and W. W. Werring of Bell Telephone Laboratories. Such a meeting should be valuable as an educational effort, for the present confusion about impact testing in America is well illustrated by a paragraph in the A.S.M.E. Unfired Pressure Vessel Code, which sets up acceptance values based on a "standard A.S.M. 10x10-mm. specimen," either Charpy or Izod with a keyhole notch, despite the fact that the A.S.M. is not a specification writing body and therefore has no "standard 10x10-mm. specimen," and further that the Izod universally carries a Vee notch!

Dr. Giolitti in a letter on page 164 decries the lack of agreement on the *form* of impact test piece. European engineers are agreed on a 10x10x55-mm. test bar tested as a simple beam (Charpy test). They are also agreed on the Mesnager notch, parallel sided with bottom rounded to 1-mm. radius, but the total depth is 3 mm. in Germany, 2 mm. in Italy and 5 mm. in France. In England the favorite is the Izod test (cantilever beam, 10x10x75 mm., notched with a 45° Vee notch of 2 mm. total depth and bottom rounded to 0.25-mm. radius). The A.S.T.M. has a tentative specification (E23-34T) illustrating this English test piece, but further complicates matters by calling for a Charpy test bar with this same Izod Vee notch!

Such differences in test bar dimensions are important, for it has been shown that if test bars of various sizes but proportional dimensions are made of a high quality and uniform steel, the impact strengths so derived cannot be readily correlated in any system of units; in other words, the principle of similarity does not hold. Worse than this, it is frequently found that a series of uniform test pieces of a single steel made with great precision will give results which scatter far more than, say, the hardness, tensile strength or elongation. Again, a series of steels of variable impact strengths may be ranged in one order from toughest to brittlest by the Izod test, in another order by the Charpy test with 5-mm. notch and still another by the Charpy test with 1-mm. notch. Finally, steels which

have a very low impact value by these tests perform satisfactorily in service — for example, rails — and parts which have failed under impact often show excellent Izod strengths when subsequently investigated.

Facts such as these have quenched most of the interest American engineers have had in impact testing, despite the vivid realization that many important machine parts have to resist shock and some measure of their inherent ability to do so is urgently needed. Interest has recently been revived by investigators in two fields: First, in the difficult matter of hardened toolsteels G. V. Luerssen and his associates in Carpenter Steel Co. have shown that a torsional impact test will distinguish the structural changes occurring during tempering. More important perhaps is the work of H. C. Mann and co-workers at Watertown Arsenal. They find that when a small tension test piece of low alloy or carbon steel is broken in impact at Charpy or Izod speeds the energy absorbed is the same as that measured by the area under the stress-strain curve made at a slow rate in a tensile testing machine, when the stress is computed on the reduced area actually carrying the load rather than the original diameter of the specimen (see METAL PROGRESS, March 1935), and further that the energy absorbed in impact failure at really high speed is usually much lower than at a moderate speed. Col. G. F. Jenks said that this conception of critical speed of blow, above which the steel breaks more easily, had explained several puzzling occurrences in ordnance not solved by ordinary notched bar impact tests.

H. J. Gough of the National Physical Laboratory (England) recounted some history to support his contention that the idea of critical velocity is not new, Stanton and Bairstow having discovered it about 30 years ago. He recalled the beginnings of the test to show why British engineers place considerable store on its indications. Rough impact and bending tests have doubtless been made ever since the dark ages, but when low carbon bessemer steel began to supplant wrought iron, boilermakers found that some pieces of the new steel, indistinguishable from satisfactory pieces by analysis or tensile test, would crack badly, especially when worked at the so-called blue brittle heat. Since the notched bar impact test was able to distinguish between good and unsatisfactory steels of this sort, it attained considerable vogue. Dr. Gough also said that impact strength should not be regarded as an absolute virtue — for instance, if experience shows that a certain metal with 40 ft-lb. is quite satisfactory for a given service, an 80-ft-lb. steel as well as a 20-ft-lb. steel should not be accepted without other strongly favorable evidence.

He wished to raise a distinction between the properties of "brittleness" and "notch brittleness" in a metal, and inferred that a tensile impact test on a smooth bar would not indicate the presence — or absence — of "notch sensitivity," a property which many engineers think very important. Prof. A. V. de Forest of Massachusetts Institute of Technology testified, however, that in his experience, failures in service are due to a mechanical notch, or scratch on the surface, or some internal notch or other stress-raiser underneath, rather than on low impact properties of the material as a whole. Prof. H. F. Moore of University of Illinois also was of the opinion that a slow tensile test on a notched specimen might show everything that a Charpy or Izod test would. A. B. Kinzel of Union Carbide & Carbon Corp. further pointed out that a distinction between "brittle" and "notch brittle" was begging the question, because all commercial structures are notched. The inference was that in certain services metals are required which are able to absorb impact energy even where stresses are concentrated at internal or external notches. Other speakers noted that the action of crane chains and hooks indicated that cold-worked surfaces were frequently equivalent to sharp external notches, as far as inducing brittle fracture is concerned.

Trouble with crane chains occurs so frequently in frosty weather that a careful foreman will "draw the chain through the fire" before lifting heavy loads. This brings up the question of a critical temperature for brittleness. Disregarding the so-called "blue brittle" range, the relation of temperature to impact strength is typified by the set of curves at the bottom of page 140, from work by Messrs. Rotscher and Fink of Aachen (METAL PROGRESS, December 1933). As Dr. Gough pointed out, such curves for pearlitic steels are of an S type, and this is generalized in the second diagram, at middle of page 141. Prof. J. M. Lessells of Massachusetts Institute of Technology lent some clarity to the definition of toughness and brittleness by citing Moser's work, indicating that tough fractures are of the shearing type with considerable ductility, whereas brittle fractures are of the separation type. One can often be changed into the other by

presence or absence of certain types of notches or by changing the geometry of the test piece.

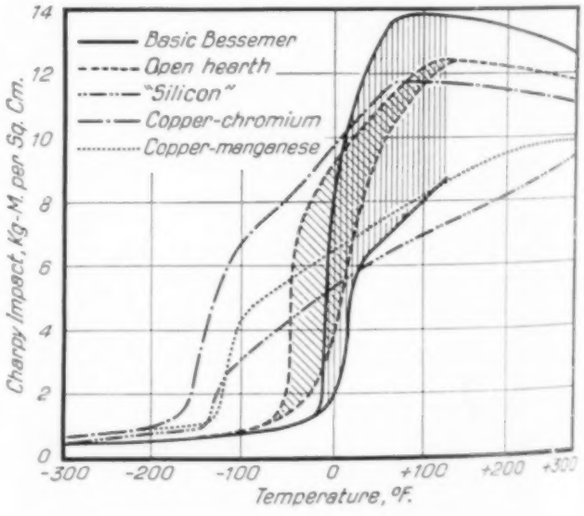
This S curve was found useful by the Editor of METAL PROGRESS in a lecture course on alloy steels when discussing the relationship of analysis and heat treatment to toughness. It has far more than academic interest, for it involves the safety of aircraft high-flying in northern winters, chemical equipment at very low or very high temperatures, and even the prevention of temper brittleness in certain steels working at atmospheric temperatures. Indeed the range from a blistering summer day to a winter cold snap may readily encompass the entire steep portion of the S curve for ordinary carbon steel.

Analysis of the steel has much to do with the location of the steep portion of the curve — that is, the actual temperatures t_1 and t_2. (We must neglect the solid solution alloys monel metal and 18-8 stainless steel, which retain their toughness substantially unchanged to liquid air, and confine attention to the other alloys heat treated to some conglomerate of ferrite and carbide.)

Normalized mild carbon steel (0.15 to 0.20% C) increases sharply in toughness as the temperature rises from —30° F. to +75° F. This is shown by Curve *C* of the third group at the top of the next page, the approximate median of Rotscher and Fink's results. Messrs. Egan, Crafts and Kinzel find that these temperatures for t_1 and t_2 are lowered by 75° by the addition of 0.45% vanadium (Curve *B*), and 150° by the addition of 0.65% zirconium (Curve *A*); likewise that chromium-copper steel, aluminum killed, has t_2 somewhat below —150° F. R. K. Hopkins in a paper for A.I.M.E. in 1935 recommends 0.15% C, 2.25% Ni, 0.50% Mn for low temperature petroleum equipment, and for this steel in normalized condition t_2 is about —75° F.

Mr. Hopkins notes that this 2¼% nickel steel has deficient impact at —75° F. if air cooled from a flanging heat, and therefore recommends subsequent normalization from 1525° F. This is but one of many indications that variations in microstructural condition will shift the S curve either to right or left, or steepen the gradient between t_1 and t_2. Since room temperature (normal testing temperature) falls within this range for the mild carbon steels tested by the German investigators, it is seen there will be plenty of reason for erratic results in impact tests on such metal.

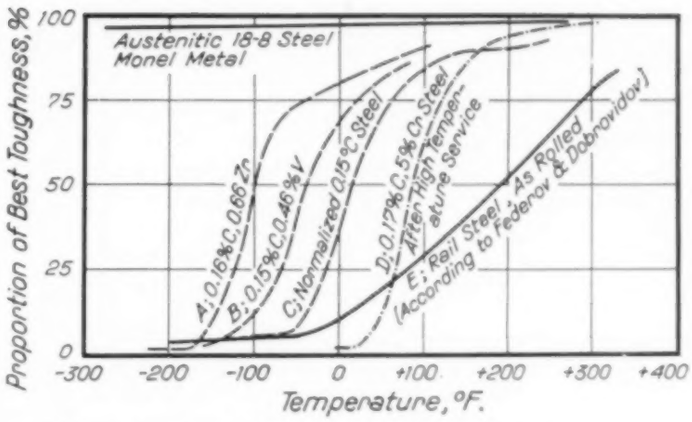
The situation as to temper brittleness appears to the Editor to be something like this: A nickel-chromium steel like S.A.E. 3435 (0.35% C, 3% Ni, 0.80% Cr) when properly treated has a temperature t_2 substantially below room temperature; its Izod impact may be 70 ft-lb. and the fracture fibrous. However, the nature of the ferrite is such that if the metal is tempered a long time at low temperatures (say 850° F.) or slowly cooled rather than water quenched from a short temper at higher temperatures (say 1100° F.), the Izod impact is erratic, perhaps no more than 35 ft-lb., and the fracture crystalline. These facts conform to the view that incorrect heat treatment brings the temperatures t_1 and t_2 closer together and also shifts the S curve from some position like *B*, in the sketch, to the right as at *D*, so that room temperature is fairly low down on a steep portion of the toughness-temperature curve.



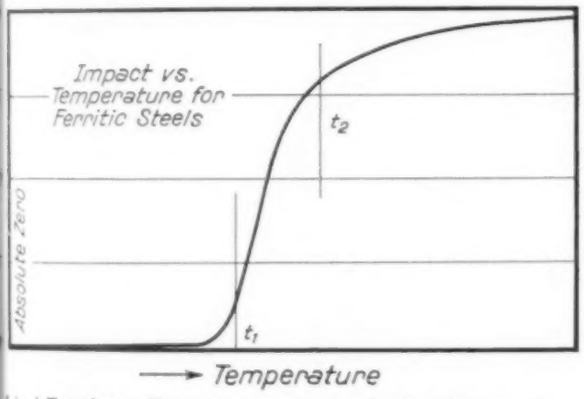
Steel	Analysis							Heat Treatment	
	C	Si	Mn	P	S	Cu	Cr	Temperature °F.	Cooling
Basic Bessemer	0.04	0.01	0.37	0.066	0.046	0.09	—	1700	Air
Open hearth	0.15	0.01	0.57	0.024	0.030	0.18	—	1700	Air
"Silicon"	0.15	0.89	1.12	0.053	0.036	0.10	—	1560	Furnace
Copper-chromium	0.15	0.36	0.87	0.022	0.026	0.85	0.51	1560	Furnace
Copper-manganese	0.19	0.50	1.09	0.016	0.025	0.60	—	1560	Furnace

Relationship Between Toughness as Indicated by Charpy Impact Test and Temperature of Sample for Several Carbon and High Strength Steels Made in Germany (After Rotscher and Fink; See Metal Progress, December 1933)

While this is an easy visualization of the relationships, it is no explanation of the essential cause of temper brittleness. It may be useful, however, to indicate how these concepts apply to tubes for petroleum stills, made of 5% chromium steel (without tungsten or molybdenum). E. S. Dixon and his associates of The Texas Co. find that new tubes have toughness measured by Charpy test with Izod notch of 100 ft-lb. After two or three years' service at 900 to 1200° F., they only have 30 ft-lb. toughness (both measured at 70° F.) and are likely to crack when cleaned during winter shutdowns — in other words, the toughness is much less than 30 ft-lb. at 20° F. If impact test pieces of these failed tubes are heated in boiling water and tested at that temperature, their toughness is high, and as a matter of fact,



18-8 and Monel Metal Retain Practically All Their Toughness to Liquid Air Temperatures, but Carbon and Low Alloy Steels Are Embrittled Below Certain Temperatures Depending on Analysis and Previous Heat Treatment



Ideal Toughness-Temperature Curve of a Ferritic Steel

no brittle fractures have developed *in service* at high temperatures.

This all conforms to the idea that long heating at 900° F. or over changes the properties of the chromium-ferrite in this steel so that the original S curve with t_2 below room temperature (something like Curve *B*) has moved over to position *D*, where t_2 is more like 175° F., and t_1 is well above zero. Obviously the operating temperatures are out along the upper end of the curve, where toughness is ample.

C. E. Margerum of the U.S. Navy, Bureau of Ordnance, called attention to the fact that as a rule non-ferrous metals do not become brittle at moderately low temperatures — or at least have no well-defined S curve as above described. He did bring out one item of importance in the practical application of impact data and that is the mass effect, citing as an instance heavy steel castings which exhibit satisfactory ductility in a standard test bar, but break with a "brittle" fracture when overloaded in sections 3 or 4 in. thick. Other speakers mentioned the same phenomenon: Welded pressure vessels with massive walls, when tested to destruction, have less and less ductility in the fracture as the thickness of plate increases and the design lends additional rigidity to the structure. In other words, thin-walled vessels develop shear type fractures, thick-walled vessels develop separation type fractures, whereas vessels of equivalent strength but made of nested, closely fitting units again develop shear type fractures.

It is believed that constraint in two or three dimensions has much to do with brittle breaks in metal which has great ductility when tested in small test bars. For instance, if a pipe is stretched longitudinally at the same time hydrostatic pressure is applied internally, failures without elongation can be produced — an experiment that does much to explain the hydraulic engineer's principle that a hydraulic, steam or other pressure pipe must not be anchored securely without expansion joints.

Summarizing the discussion briefly, it appears that at least four factors have important influence on the impact test of a given metal and the impact resistance of structures made of it, namely, the temperature, the velocity of the loading, the nature of the notch and the constraint or mass of the resisting metal. Since most of these factors have hitherto been allowed to take care of themselves, it is not surprising that impact testing, as done in the past, has yielded results which have bewildered the careful engineer.

John B. Tytus

VICE-PRESIDENT, AMERICAN ROLLING MILL CO.

JOHN B. TYTUS

ORDINARILY one would not imagine any connection between paper and steel. But as a matter of fact, the steel industry owes the paper industry a debt, for it was from the paper mill that John B. Tytus, of Middletown, Ohio, drew his initial inspiration for the continuous process of rolling sheet iron and steel.

Mr. Tytus is a vice-president of The American Rolling Mill Co. and invented the first successful continuous mill for wide sheets, which his company installed at its Ashland, Kentucky, plant in 1923. For this significant contribution to the progress of steel industry he was awarded the Gary Memorial Medal by the American Iron and Steel Institute in 1935.

But what of this strange link between paper and steel?

Well, Mr. Tytus came of a pioneer family in the Miami Valley. His father and his father's father had been in the paper milling business. As a boy he naturally had spent much time in the paper mills, following at first the crude and costly hand method of production, and observing later the introduction of mechanical methods which made paper a commodity instead of a luxury. Following his graduation from Yale in 1897, he spent several years in the paper mills, but the pioneering improvements had by this time been made, and the inventive mind of Mr. Tytus sought for new fields.

In 1904 he visited the plant of The American Rolling Mill Co. which had located in his home town of Middletown some three years before. Of his visit of inspection, he later said:

"I counted twenty-two separate operations, all by hand. I knew there were more. I was astounded at the amount of handling. In the paper industry we had already solved the problem of continuous production. I knew that these old methods couldn't last in the steel industry — that they would have to be changed."

John Tytus had found where he wanted to be, and at once applied to another young man, Charles R. Hook, now president of A.R.M.Co. and then its superintendent, for a job. In later years the teamwork of these two men — Tytus experimenting and Hook helping and constantly encouraging — was a great factor in developing a successful plan for continuous, mechanical rolling of sheet.

The method of sheet rolling had not shown any fundamental changes in 150 years. True, many attempts had been made to discover a successful method for rolling out sheets of wide width, but the attempts in every instance had ended in costly and disappointing failure. Theories which were then prevalent about the behavior of the metal and the mills in the process of rolling must be wrong, and to Mr. Tytus this was a challenge. The result of this challenge, as we now know, was an invention successful, instead of the failure which had bitterly rewarded the efforts of all the earlier experimenters.

Eventually the first continuous wide-sheet mill was built at Ashland under Mr. Tytus' personal direction, and the first unit of the mill was put into operation on the last day of the year 1923. As imperfections were corrected and adjustments made, production leaped up from a few tons to 1,400 tons a day!

The news of such a startling development was hard to keep a secret, and at length the company announced its continuous process to the steel world. In a few months virtually every important iron and steel man in the country, interested in the production of sheets, had visited Ashland to see the marvelous sight of sheets being made at "a ton a minute." Steel men are conversant with the rapid strides the continuous process has made since that day. With the current renaissance of business there are now enough continuous mills operating, building and contemplated to produce approximately 14,000,000 net tons a year.

It is a long way back to that day in 1909 when the recruit from the paper mill, John Tytus, sat in the little shanty which served as an office for the A.R.M.Co. works at Middletown and observed prophetically to his boss, Mr. Hook: "Some day we'll be making steel in long, wide sheets and rolling it up at the ends of the mills the way we do paper."

No idle dream, that! And it was made to come true in large part by John Tytus' own inventive genius.

Today, at 61, Mr. Tytus still likes to talk about the paper mills and the important changes and improvements which he watched and studied there as a boy. And, with characteristic modesty, he still wonders why the same kind of changes and improvements weren't made in the rolling mill before his day.

PHYSICAL FACTORS IN CASTING OF METALS

By Cecil H. Desch

Abstract of Edward Williams Lecture Before Institute of British Foundrymen (The Metal Industry, June 18, p. 680)

THE first condition of obtaining a satisfactory casting is that the metal shall flow evenly into the mold, and shall fill it completely before such freezing occurs as to offer an obstruction to its further flow. This property I prefer to call "flowing power." Roughly, the empirical values obtained for the flowing power will depend on two kinds of factors: One set depending on the conditions of the experiment, including the form, material, and surface of the mold, the casting head, and the degree of superheating of the metal before pouring, and the other set involving the properties of the metal or alloy. This second set includes viscosity, surface tension, gas content, formation of surface films, the range over which solidification takes place, change of volume during solidification, and crystal thrust. There are other factors which affect the quality of the resulting casting, although not among those which govern the flowing power. These include the contraction in the solid state, the strength at temperature near to the freezing point, the liability to segregation, and the tendency to form small or large crystal grains, the last being dependent in many instances on the previous history of the metal.

It should hardly be necessary to add that the skill of the foundrymen remains one of the most important factors, and it is not susceptible of quantitative expression.

Viscosity has been credited with far greater influence on the flowing power than it actually possesses. Viscosity of all liquid metals investigated is less than that of water, and the apparent molasses-like action of some metals is either due to a thin and tough surface film or the presence of many tiny gas bubbles producing a metal foam. Neither is diminished flowing power during the process of freezing (cooling from liquidus to solidus) due to increased viscosity of the remaining liquid but to obstruction of the channels by growing crystals.

Surface tension of a metal or alloy is another physical property which may affect the casting quality. Molten metals do not "wet" their molds. In a narrow channel, therefore, there is a resistance to the flow of the metal owing to its surface tension, but this effect becomes less and less marked as the diameter of the passage is increased. Actually, the amount of the resistance so produced is small in most castings if the metal has a clean surface.

Surface Films — A surface film of a foreign substance affects the flowing power far more than any possible variation in the true viscosity or in the surface tension. Aluminum provides a striking example. On exposure to air, aluminum forms immediately a thin layer of the oxide, alumina. That film has such strength that it is possible to melt a long, freely suspended loop of aluminum wire by passing an electric current through it, without rupture, the skin being strong enough to retain the weight of the molten metal. This property of aluminum also affects alloys in which it is present. The difficulty of casting aluminum bronze (the copper alloy containing 8 to 10% of aluminum) is caused by the formation of such a tough skin, which hinders pouring and, by becoming broken into fragments, is entangled in the metal as dirt.

When the oxide is soluble in the molten metal, no film is formed, so that copper, iron, and nickel pour in a clean stream, although they may contain solid matter in suspension. Moreover, if two of the constituents of the alloy can form a mixture of oxides with a lower melting point than that of the alloy itself, the surface film will be liquid instead of solid. This, of course, is the case when a flux or a deoxidizer such as phosphorus has been added.

At the National Physical Laboratory it has been found by the method of electron diffraction that the film formed on molten tin may be either smooth and compact, or bulky and corrugated, the bulky form allowing oxidation to go on rapidly, while the other is protective. The difference corresponded with a difference in the arrangement of the minute crystals of the oxide, the loose film having the crystals arranged at random, while the compact skin had a definite "preferred orientation."

Freezing Range — While a pure metal freezes at a constant temperature, in most alloys the process extends over a range, and the extent of this range is of importance in determining the flowing power. *(Continued on page 196)*

COPPER-LEAD BEARING METALS FAVORED FOR SEVERE SERVICE

By Francis G. Jenkins
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PRESENT DAY demands of bearing materials for high speed engines have been frequently met by the steel-backed copper-lead bearings, which have replaced babbitt because of the latter's weakness against repeated flexing at increased speeds and bearing loads. Likewise the physical characteristics of copper-lead alloys are less affected by temperature, the material will not seize, and overheating does less damage than it does to babbitt. Originally developed by the railroads, the progress of copper-lead alloys was immeasurably assisted by the discovery of means of producing a uniform dispersion of lead, including the effect of deoxidation, chilling and the addition of nickel.

While this paper is not intended to present any original data, it is intended to bring to the reader's attention a few important points concerning the development of copper-lead bearing alloys, especially as to their metallurgical aspects. Perhaps this will assist in a more enlightened approach to the practical side of bearing manufacture and maintenance.

In order to meet the present demands of high speed engines, the bearing metal must be able to carry increased bearing loads and stand up under the increased speeds and operating temperatures. A certain amount of plasticity is still desired to compensate for minute irregularities in the shaft or bearing surface by a slight amount of yielding, thereby avoiding dangerous stresses in bearing and shaft and preventing overheating and rapid wear. While some have questioned the conventional view, the best structure for a bearing metal is probably that of a soft matrix with hard particles scattered through it. The hard particles carry the load and resist wear, while the softer ground mass allows the metal to adjust itself to the surface of the shaft and equalize bearing pressure. A bearing metal of good running qualities in an engine is not strong enough to support the load itself, but is used as a comparatively thin lining in a shell of some strong and cheaper material such as steel, which in turn is fixed in a supporting structure.

Aircraft engines, almost exclusively, and many automotive and other gas engines today carry such bearings, chill cast on a steel backing, and they are mainly responsible for the high specific output of such engines. Copper-lead mixtures have superseded babbitt for many connecting rod crank pin bearings, plain crankshaft bearings, and even more generally in many accessory drive shaft bearings. The basic reason for eliminating babbitt is its low resistance to fatigue. Fatigue cracks starting at the surface eventually cause separation near the bond between the backing and the babbitt by repeated slight flexing.

An intermediate step was the substitution of steel for the bronze backing or shell, the bearing still being babbitt lined. In aircraft engines this apparently results in increasing the life of the bearing some four or five times, according to competent authorities. The relatively low resistance of babbitt itself to fatigue failure under high loads and temperature even when steel backed, brought about the present development — the adoption of a copper lining with a high lead content, still further to increase bearing life and load capacity. This has been described by A. F. Denham in *Automotive Industries*, June 16, 1934, in an article entitled "High Leaded, Bronze Lined, Steel Backed Bearings."

High Fatigue Strength Is Essential

Fatigue weakness of babbitted bearings, either steel backed or bronze backed, is due to the formation of a brittle intermetallic compound resulting from the reaction of the tin or other metals of the babbitt with the iron of the steel backing or sleeve or with the copper of the bronze backing. The copper-lead bearing metal, however, forms a solid solution with the steel backing, the copper with the iron. Since this intermediate layer is a solid solution it is much more malleable, and adhesion is maintained in spite of the inevitable deformations and vibrations encountered in service.

It is generally understood that leaded "bronzes" of this type have a melting point considerably above that of babbitt and that their physical characteristics are less affected by temperature. At elevated temperatures copper-lead mixtures exhibit a greater resistance to fatigue and deformation and a higher thermal conductivity than do babbitts. (See R. G. N. Evans' discussion of S. W. Sparrow's paper "Recent Developments in Main and Connecting Rod Bearings" in *S.A.E. Journal*, July and September 1934.) High thermal conductivity is certainly one of the requirements of a good bearing metal, for when it is placed in intimate contact with its backing, a rapid transmission of heat will contribute to long life. Copper-lead alloy appears to crush as readily as babbitt, and transitory metal-to-metal contact in service produces a film of lead which presumably has sufficient lubricating value to prevent seizing. Seizing usually occurs if a differential in expansion between the bearing material and the shaft permits the high spots of the bearing material to come into contact with the high spots of the shaft.

At any rate the copper-lead bearings have proven superior to babbitt when subjected to both overheating as well as continuous service at high temperatures.

Too little clearance, or inadequate lubrication, causes a bearing to overheat and eventually fail. While the babbitt bearing under such circumstances "burns out" and becomes unserviceable almost instantly, in the case of a copper-lead bearing the rate of wear is greatly increased and failure occurs more gradually. Apparently the lead "stews out" and furnishes sufficient lubrication to prevent serious damage to the moving member. Naturally, a failure of this sort at high speeds does not benefit the shaft or crank pin, but results thus far indicate that less harm is done when the bearing is of copper-lead. Babbitt bearings replaced after such a failure usually have a short life.

Another impelling reason for the displacement of babbitt bearings has been their inability to withstand the continuous high temperatures that do not affect the operation of the copper-lead bearings. This failure is indicated by chips falling out of the bearing. It is generally conceded that this is due to fatigue or to the development of fatigue cracks. J. Dintilhac, however, in a discussion of the general topic of lubrication in *Automotive Industries*, July 13, 1935, states that when the temperature is high enough the force of adherence between the metal and oil becomes greater than the cohesive force between the metal particles of the babbitt, and the oil dis-aggregates the metal and carries it along. This metal may later be found re-aggregated into lumps at the bottom of the crankcase.

Developed by Railroads

High lead bronzes first came into prominence as substitutes for tin and leaded tin bronzes. These latter metals are still in use today, together with aluminum bronze for bearing applications demanding similar strength. For bearing usage where the need was felt for a more plastic metal, the tin bronzes have been largely replaced by copper alloys of increasing lead and decreasing tin and zinc contents. The lead makes the alloy more plastic and therefore better able to conform to the irregularities of the service without heating. Tin also is quite expensive.

To the railroads belongs the credit for the first general use of leaded bronze. In England,

about 1870, Alexander Dick developed the 80% Cu, 10% Sn, 10% Pb alloy, which found wide usage on the railroads of that country. In America, about 1892, Dudley of the Pennsylvania Railroad completed a long series of service tests on lead bronzes showing that increasing the lead content reduced wear and overheating. His EX-B metal containing 8% Sn and 15% Pb is today one of the widely used bearing alloys in locomotive construction.

However, as the lead content increased, its tendency toward segregation became more and more of a problem. Nickel was recognized at about this time as being one of the most powerful agents to prevent "lead sweat" or segregation. Thus, in 1900 a patent was granted to G. H. Clamer and J. G. Hendrickson for a series of lead bronzes containing over 20% Pb and less than 7% Sn with 1% Ni; this is commonly known as "Ajax Plastic Bronze."

The latest leaded bronzes are still higher in lead (25 to 50%) with 1 to 2% Ni, which is particularly desirable if lead exceeds 38%. They contain none of the so-called strategic metals such as tin and antimony, which are not produced in America, and are used not only as a replacement for copper-tin bronzes but, as already mentioned, for tin-base bearing alloys as well.

Leaded bronze, steel backed, main and connecting rod bearings have been used by many prominent automobile manufacturers during the past few years. An interesting manufacturing process for copper-lead bearings for connecting rods of V-8 cars, used by the Ford Motor Co. up to a year or so ago, cast the copper-lead continuously on a properly prepared steel strip, which in turn was formed in a half circle, cut and machined to bearing size (*The Iron Age*, August 8, 1935). The mixture was of the following analysis: Lead 30 to 35%, copper 63 to 68%, iron 0.50% max., nickel 1.0 to 1.5%.

J. B. Johnson, in *S.A.E. Journal*, April 1937, gives the following composition of a bronze

Bearings, Lead Screw Nuts, and Bushings For Heavy Machinery Weigh Hundreds and Even Thousands of Pounds. Photo courtesy Wellman Engineering Co.

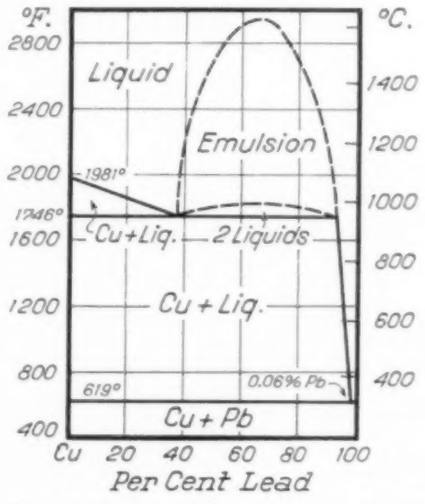
lining that has been used successfully in a number of aircraft engines:

Copper	69 to 74%
Lead	26 to 31%
Silver	1.5% Max.
Iron	0.25% Max.
Nickel	0.10% Max.
Zinc	0.15% Max.

At no point in the constitution diagram is there evidence of solid solubility of lead in copper even though the crystal structures of the metals are similar (face-centered cubic).

Under the microscope the lead appears as small globules scattered through the copper, with a small proportion on the grain boundaries. Thus it is evident that the chief effect of lead on the alloy is a mechanical one. According to the constitution diagram of copper-lead alloys, the minimum temperature for liquid homogeneity varies from 1746° F. to 2900° F., depending on the composition. Alloys between zero and 38% lead form homogeneous liquid solution immediately above the liquidus. In this range of compositions a fall of temperature through the liquidus causes separation of copper crystals from the mother liquor until at 1746° F. the liquid remaining contains 7.5% copper. On continuing the fall in temperature, further separation of copper takes place until the eutectic point at 619° F. is reached and final solidification occurs.

The acceptable microstructure of a bearing is dendritic with the lead broken up into fairly small particles and distributed uniformly throughout the mass. There are several methods of producing a fine and uniform dispersion of the lead such as chilling and deoxidation, and the addition of minor amounts of special elements. A 15% lead alloy cooled moderately rapidly and a 30% lead alloy chilled, obtain a fair uniformity of dispersion because the lead coming out of solution has no opportunity to segregate. From the constitution diagram it is noted that chilling from 2000° F. is beneficial only to those alloys of less than 38% lead. Alloys of greater lead content must be heated to progressively higher temperature to achieve homogeneity and thus obtain full benefit from the chilling operation.



If Copper-Lead Alloys High in Lead Are Heated High Enough to Destroy the Emulsion They Cannot Be Chilled Fast Enough to Prevent Segregation of the Lead. Small additions of nickel move area marked "emulsion" to right

Effect of Alloying Elements

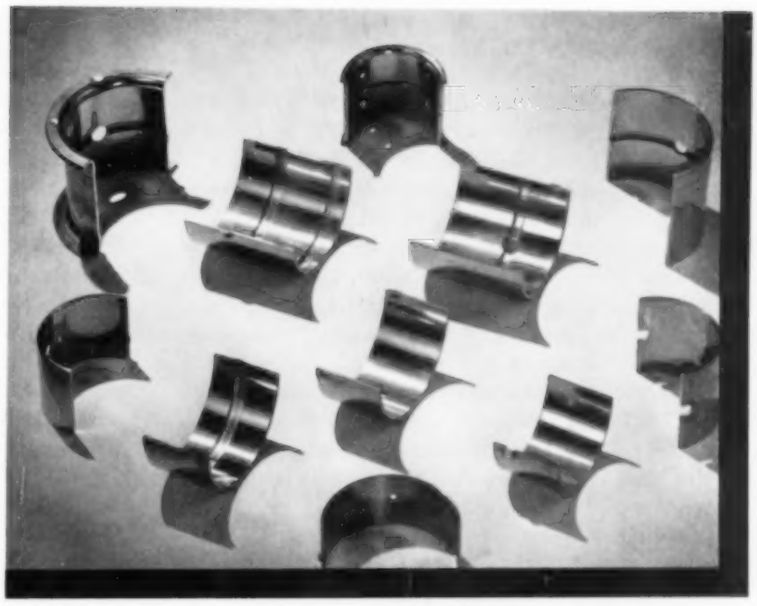
Nickel — There are probably two reasons for the action of nickel in preventing lead segregation. First, the nickel causes the metal to set somewhat more quickly, and second the addition of nickel to copper actually increases the solubility of lead in molten copper. Whereas pure molten copper can dissolve only about 38% of lead, the addition of 2.5% of nickel enables it to take up 60% or more. The quickening of the rate of cooling is accomplished by some unexplained property. It is recognized, however, that grain refinement can often be obtained by addition, before casting, of suitable elements which form compounds of high melting point. The rapidity of set obtained may therefore be caused by small nuclei of an insoluble compound formed in the molten metal before general solidification takes place.

Zinc is an adulterant which usually enters copper base alloys through the use of scrap. It is generally conceded that considerable zinc in the presence of fairly high lead content has the detrimental effect of causing the alloys to be somewhat weakened under the influence of elevated temperatures. Zinc adds to the brittleness, which accounts for the more rapid rate of wear when it is present. The best bearing bronzes do not contain zinc and its presence is restricted to below 1.0% in the specifications of consumers.

Phosphorus may be added to high leaded bronzes as it plays the part of a deoxidizer with respect to the copper. Additions of less than 0.05% are rarely harmful but do little good unless they represent a distinct excess after oxides have been reduced. Above 0.05% in the metal causes the appearance of the free Cu_3P and a reduction in the mechanical properties. Phosphorus probably serves in a dual capacity.

not only cleansing the metal but possibly furnishing nuclei of high melting that hasten cooling and thus aid in more uniform dispersion of the lead.

Silver — In cases where slightly elevated temperatures are to be encountered in service and the superior properties due to cold working are desired, the importance of selecting a grade of copper with high recrystallization temperature will be obvious. Silver has rather a small effect on the mechanical properties and electrical conductivity, but has as great an effect on the recrystallization temperature of copper as any element, and for this reason may be added to copper-lead alloys.



Modern Automobile Bearings Are Almost All Steel With Very Thin Surface Layer of Bronze, Machined to Jewel Accuracy. Photo courtesy Cleveland Graphite Bronze Co.

LEAD BRONZES IN ENGLAND AND GERMANY

Abstracted from

(a) "Copper and Its Alloys in Automobile Design" by D. P. C. Neave, *Journal*, Institution of Automobile Engineers, July 1937, page 24

(b) "Zur Frage der Blei-Bronzen" by Willi Claus *Metallwirtschaft*, January 29, 1937, page 109
Abstract and Comment in *The Metallurgist*, June 1937

IT IS INTERESTING that two summaries of views on copper-lead bearings have appeared quite recently abroad, one in England and the other in Germany. The first mentioned is a part of a more general discussion of copper in British automobiles; the author, Mr. Neave, is general manager of the Copper Development Association of London.

He notes that the Air Ministry specification D.T.D. 229 for "lead bronze" calls for approximately 75% copper, 25% lead, with up to 1.2% tin. This small percentage of tin helps to diffuse the lead evenly through the copper, but it reduces the thermal conductivity of copper by nearly one-half, and in general it appears better to keep tin or other addition agents as low as possible. For use against crankshaft steels in accordance with present average automobile practice there is probably something to be said for still higher lead contents such as 65 : 35 by weight, and 55 : 45, which are now in use.

Some troubles ascribed to corrosion by the lubricating oils have also appeared in England. "Breaking-in oils are seldom used over there, the term meaning oils containing fatty acid additions, such as 1% or more of oleic acid. This acid is supposed to cause differential washing away of the lead, leaving the copper matrix. Such a condition can be produced artificially by many hours of running with high bearing loads and acid oil at abnormally high oil temperatures of the order of 250° F., although even under these extreme conditions the denuded copper matrix does not damage the shaft at all in the same manner as would a bare steel shell. With ordinary oils the problem is one of acid formation due to oxidation, but with cooler crankcases and the generally improved oil cooling now employed, trouble need not be expected. In fact, when temperatures mount high due to unforeseen troubles, copper-lead bearings have been found to have outstandingly good qualities.

Copper-lead bearings have been employed in a number of designs for heavy duty big-ends and main engine bearings, chiefly where over-all space is restricted, because they have been found to permit an increased loading of about 25% by comparison with tin-base bearings. This somewhat dangerous generalization about loading is only quoted to give scale to the problem, and does not imply that copper-lead should displace tin-base

bearing metals except where design limitations enforce it.

Under comparable conditions there is little difference between the effective coefficient of friction of the two types of bearings. The copper-lead bearing, although possessing excellent thermal conductivity for the dissipation of hot spots, does not possess the facility for dispersing tight spots by superficial fusion to the same extent. It is therefore desirable to give copper-lead bearings increased clearance; for instance, if a given tin-base bearing has 0.001 in. clearance per in. of shaft diameter, the corresponding copper-lead bearing should be given about 0.0015 in. clearance per in. This need for increased clearance has also been attributed to greater thermal expansion, although this is difficult to justify. [Another explanation is given in the German paper to be quoted later.—Editor.]

They Have Some Disadvantages

Mr. Neave notes that much of the success of the high lead bronzes is due to successful manufacturing technique which places a high copper alloy next to the clean steel backing and hence gives the strongest bond, yet gradually increases the lead to a maximum at the wearing surface. Such manufacturing technique is generally held as a trade secret.

The German article mentioned at the outset is abstracted in **The Metallurgist** and the reviewer adds a comment as to British practice which may now be quoted:

"The author does not touch on the tendency of lead bronze to score the shaft as compared with white metals, nor on the necessity to use hardened steel for crankpins and journals. These, together with the relatively high first cost, are among the chief factors hindering the wider use of steel-backed lead bronze bearings in England, and it is probably true to say that in this country such bearings are not used in a particular application until it has been demonstrated beyond doubt that white metal is incapable of giving the service required. This having been said, it must also be agreed that in these cases steel-backed lead bronze bearings have been extremely successful. Truck and certain aero engines provide examples where this type of bearing has made all the difference between the failure and success of a design."

Germans are considering the bearing problem from the standpoint of the strategic metals copper and tin, whose consumption is there closely restricted. The greatest opportunity for savings appears in the solid bearings; the service to be expected from them is known, and years of experience have confirmed the suitability of lead bronzes for the largest types of bearing.

The consumption of non-ferrous metals is only affected to a limited degree by a simple substitution of lead bronze for tin bronze and gun metal in solid bearings. Even such small saving as is achieved in this way is likely to be outweighed by foundry losses. If the substitution can be accompanied by a reconsideration of design, however, substantial economies can be effected, since advantage can then be taken of the remarkable load-carrying capacity of lead bronze. This generally permits a reduction of the length of the bearing, and, in consequence, a saving of 25 to 30% in the metal required.

If a solid bearing can be replaced with a steel shell lined with a thin layer of copper-lead, the saving in copper is even more striking. In a particular grinding spindle a weight of 6 oz. of lead bronze in the form of a lining in a steel shell sufficed to replace a solid tin bronze bush containing 14% tin and weighing 30 lb.!

Mr. Claus continues with a discussion of assembly and operating problems, noting that the methods used in the final machining of bearings lined with lead bronze are governed by the fact that lead bronze does not "run itself in" in the same way as white metal; a lead bronze lining is not scraped to fit, therefore, but must be finished by fine boring, preferably with a diamond tool.

It is partly for the same reason that the clearance, with gravity lubrication, must be larger with lead bronze than with white metal bearings. The specific friction between lead bronze and oil is relatively high, and this also demands a fairly generous clearance. Normal German practice in engine bearings is to use a clearance of 0.001 to 0.0015 times the journal diameter.

Small Clearances Permissible

Generally, a decision as to the correct clearance to be adopted can be arrived at only by a separate consideration of individual cases. Thus, it is necessary to distinguish between the conditions in a light diesel engine, with high dynamic loading and relatively great deflections of shaft and crankcase and those in machine tools. Among machine tools, again, there are two classes — one employed for fine machining with low static loads, and the other in which rough cuts cause strongly alternating stresses.

Where necessary, however, extremely small clearances can be used quite safely with lead bronze bearings provided the oil pressure is sufficiently great. Thus, in certain machine tools, diametrical clearances of 0.0005 to 0.00075 are possible with oil pressures of 4 to 6 atmospheres. The low coefficient of expansion of the steel shell in bi-metal bearings is advantageous in maintaining such small clearances uniform and bearings of this type become almost indispensable for operations where the highest precision must be maintained.

DIAGNOSIS OF METAL TROUBLES IN INDUSTRY

PART III –

CARBURIZING

By J. L. Burns and V. Brown
Republic Steel Corp. Chicago District

TROUBLES arising in the forging of metals were illustrated in the April issue of METAL PROGRESS. A second series, printed in June, had to do with troubles due to faulty grinding or machining operations.

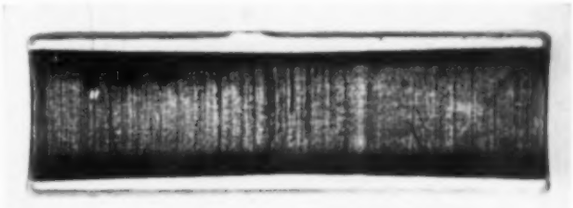
Troubles — some rare and some common, which are encountered in carburizing and the treatment of carburized parts — are illustrated in the following few pages in this issue, and this Part III completes the series.

Most troubles are very simple on diagnosis and very irksome on occurrence, but practically all are associated with fundamental facts with which we are all familiar. The origin of most trouble is in the lack of application, or an improper application, of well-known facts to the particular job. Carburizing has been done so long, and so much scientific study has been given the process that many operating troubles seem almost inexcusable. Yet they constantly occur. Witness the following items which we have classed as Spotty Depth; Carburizing Thin Sections; Heavy Cases; Thin Cases; Grain Size Effects; Overheated Work; Poor Subsequent Heat Treatment.

Transverse Section of a Carburized Piston Pin Photographed Double Size

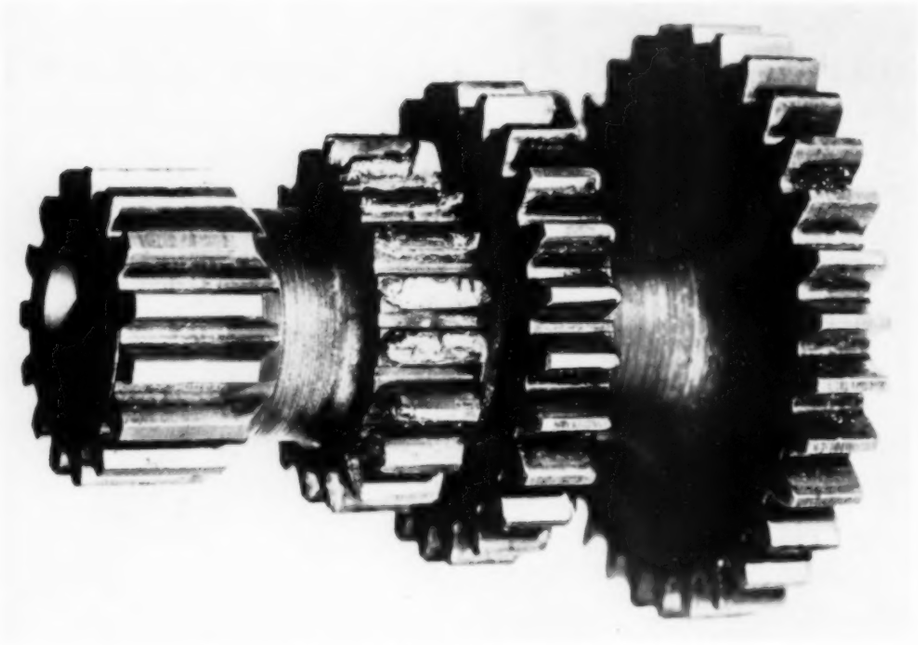
Spotty Depth

Improper packing for carburizing, such as placing the parts too close together or failing to clean the parts of surface contamination, will cause variations in the case depth, not because the steel is variable or unsuitable, but because portions of the surface are mechanically excluded from sufficient exposure to the carburizing gases. The two photographs show such uncarburized spots on the external surface of a tubular piston pin, prepared for examination. The general depth is just about right, but it's spotty.



Longitudinal Section, Actual Size

TOO THIN A CASE WILL CAUSE TROUBLE

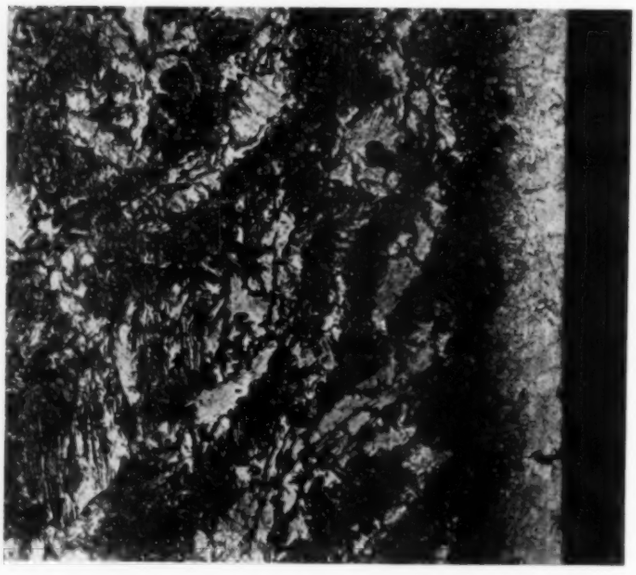


Gears Like This Are NOT Unusual

Thin case is a common cause for tooth failure. As shown in the above photograph of an automotive gear cluster, thin case can be responsible for crushed teeth when heavy loads must be carried. Many mutilated teeth were cut out of this gear, cross-sectioned and etched to show the depth of case, and this was found to average about 0.02 in., whereas for a tooth of this size and service, at least double that depth of case would be regarded as good practice. Even though such complete and disastrous breakdown does not occur, too thin a case is commonly the cause of rapid wear of tooth surfaces or gears.

The above is an interesting example of serious trouble resulting from an attempt to hurry the work through the carburizing furnace in too short a time.

This IS Unusual



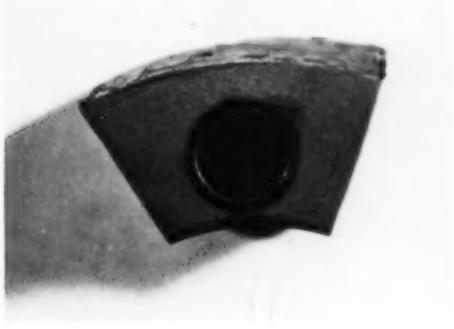
The photomicrograph at left at 100 diameters is a cross-section through a case which turned out to be only 0.005 in. thick. A question whether such an excessively thin surface layer was due to too short a time under proper conditions, or too low a temperature for carburization to proceed at a reasonable rate was answered by the microscope. Temperature was too low, for remnants of the forging structure are still apparent in the case.

Sometimes small, spindly or flat parts such as typewriter bars are carburized, and then it must be done at low temperature (say 1400° F.) since normal practice would carburize the parts to the very center.

CARBURIZING THIN SECTIONS

Since low carbon steels are used for carburizing, the process gives the part a hard, wear resisting case which extends in from the surface a short distance, and a soft, low carbon core which gives the part the necessary ductility and shock resistance. If a given part, subjected to high impact service requirements, has some thin sections, they are apt to carburize completely through (or nearly so), giving the part undesirable brittleness at these points. The two figures herewith show portions of machine sections having thin walls; the smaller view is a piece that has been polished and etched to show it to be carburized nearly through at the point where the drill hole is near the surface.

Selective carburizing or finish machining after carburizing may be resorted to in order to avoid this condition and associated trouble.



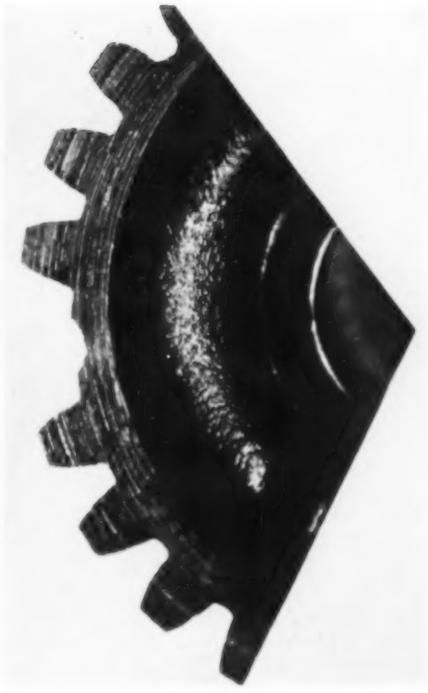
HEAVY CASES ALSO GIVE TROUBLE

A segment cut from a damaged gear is shown at the right. An extremely deep case caused excessive brittleness in the teeth of this gear, and a tooth broke out under heavy load.

Another tooth was knocked off this gear, sectioned and etched. The lower view, at six diameters magnification, shows the conditions.

Case depth in this gear should have been about 15% of the width of the tooth at the pitch line. The micro shows that no true core (upon which ductility is dependent) is present — only a transition zone.

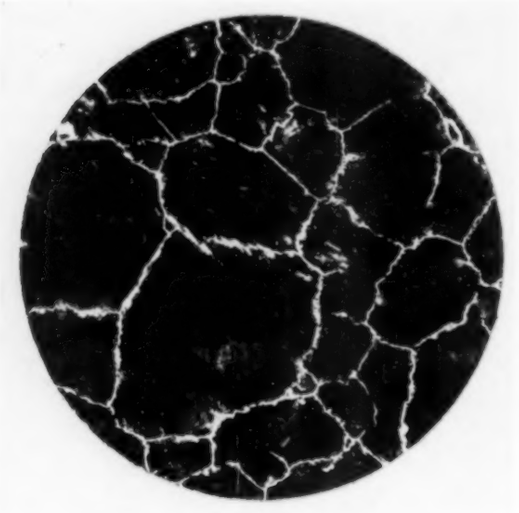
The depth is too great.



GRAIN SIZE CONTROL AVOIDS TROUBLE

Considerable trouble with carburized parts in service is still encountered and frequently this is due to a "brittle case." Use of a coarse-grained steel is one of the reasons for a brittle case, as is illustrated in the photomicrographs below. This cause was much more prevalent before the advent of modern steel mill practice which leads to grain size control.

"Fine-grained steel" in this instance means steel which retains a fine austenitic grain after 8 hr. in a carburizing pot at 1700° F. — a size number of 6 to 8 on the A.S.T.M. chart, or 32 to 128 grains per sq.in. on a micro at 100 dia. Use of such steel for carburizing has eliminated coarse grain from its former classification of *common* trouble of brittle case.

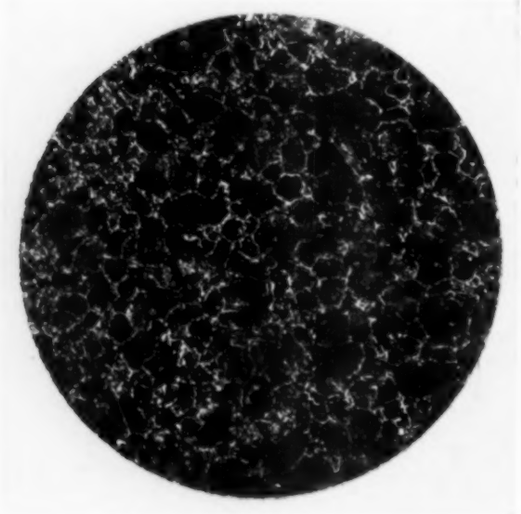


Magnification 100 diameters

Coarse-grained steel like this, when quenched from the carburizing temperature (1700° F.),

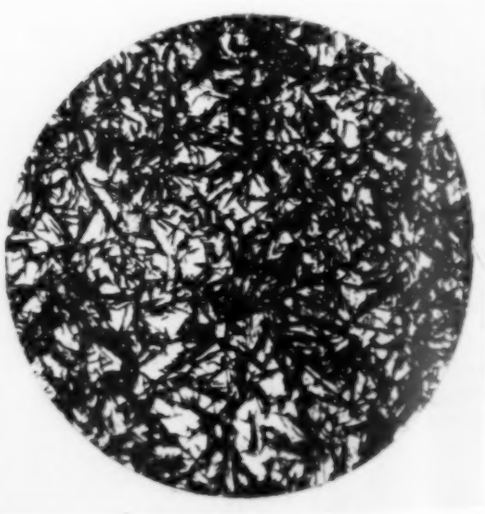
Magnification 500 diameters

will have a coarse, martensitic structure like this, resulting in a comparatively brittle case



Magnification 100 diameters

Fine-grained steel like this, when quenched from the carburizing

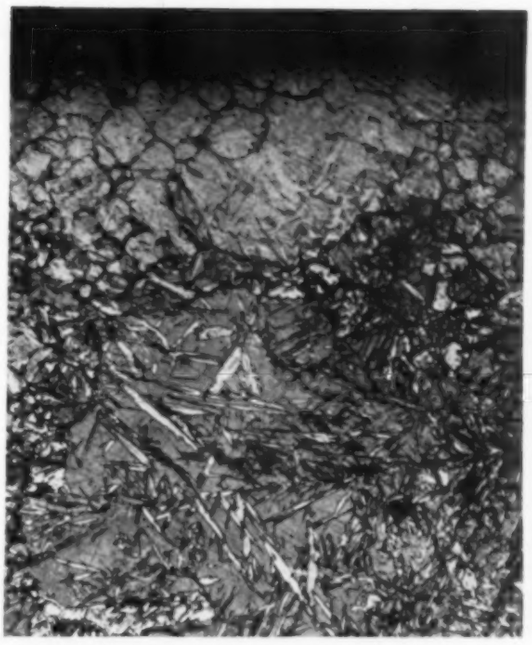


Magnification 500 diameters

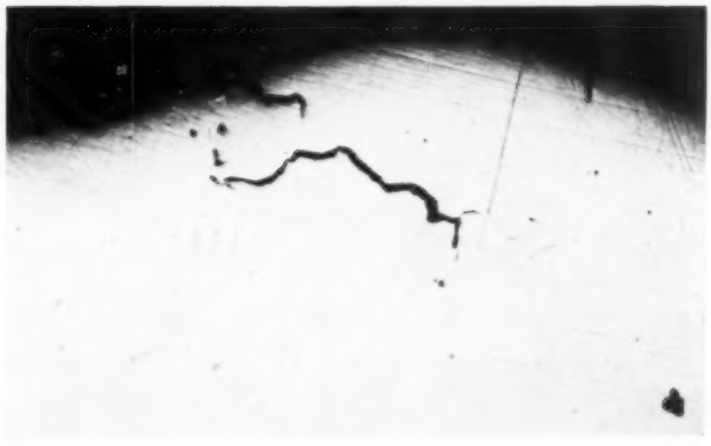
temperature (1700° F.) will have a finer, tougher case like this

THIS TROUBLE IS RARE

These pictures show the overheating and burning that occurred on the top of a few teeth on a carburized gear during its subsequent heat treatment. Although trouble of this nature is comparatively rare it does illustrate the fact that things thought impossible *do* happen in the course of processing. The failure of this gear was due to the overheating and consequent coarse, brittle structure at the teeth — especially in the case.



Such a condition is most apt to happen in the older type of gas furnace, hand controlled, where the flame can impinge directly on the work during heating for hardening. The high carbon case with its comparatively low burning temperature is affected early by a hot spot so occurring when flame temperature is high.



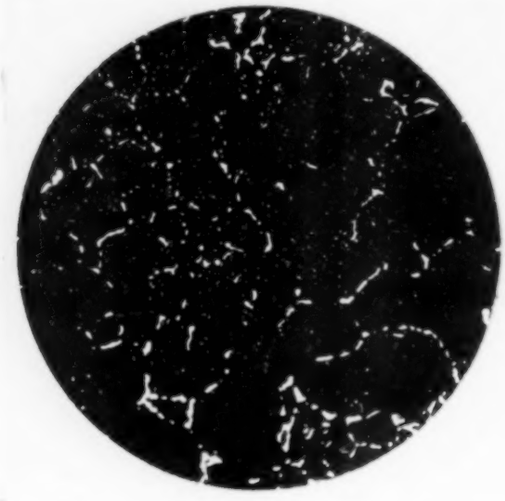
The top figure at 100 diameters shows the coarse austenitic grain size developed near the surface, indicative of overheating. The middle and bottom figures, both taken at 200 diameters on the same spot — a corner of a tooth — show actual burning. The unetched view shows an open crack, and the etched view locates it along the crystal boundaries.

BAD AND GOOD HEAT TREATMENT

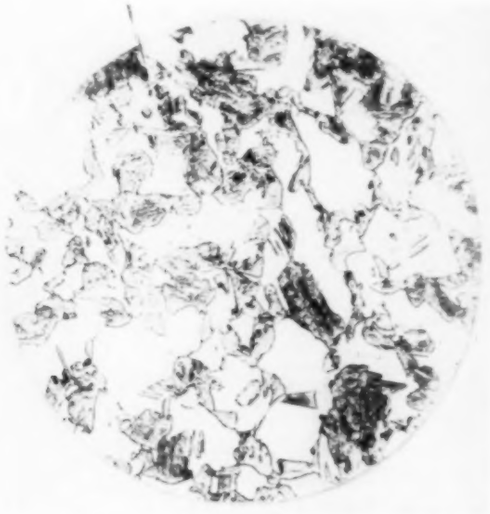
Aside from such an inexcusable overheating at the surface as illustrated on the preceding page, a common cause of failure is underheating during treatment after carburizing. Corners of such faulty parts may chip off due to incomplete solution of the hard, brittle carbides at grain boundaries, as shown in the top left micro. Or, the case may crack under load for lack of proper support by a core which may be "out of solution," as shown at top right.

Photomicrographs at the bottom of the page illustrate a case and a core both "in solution," as may be obtained from a direct quench from the box or after reheating to a temperature sufficiently high to get both the excess cementite in the case and the surplus ferrite in the core in solution.

Where case or core or both are "out of solution" a coarse-appearing fracture with associated brittleness is commonly observed.

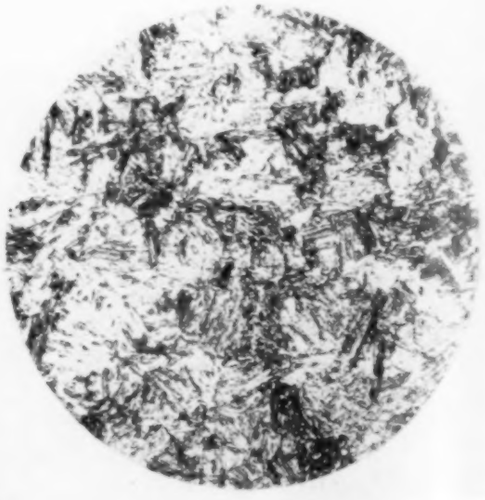


Case Etched to Show Undissolved Carbide. X500



Core Etched to Show Surplus Ferrite. X500

Examples of Case and Core Heated Too Low or Too Short for Solution of Excess Constituent



Examples of Case and Core at 500 Diameters When Part Is Quenched From High Enough Temperatures to Put Both "in Solution"

Crystallography of the Chemical Elements

As Tabulated by William Hume-Rothery
in "The Structure of Metals and Alloys" Monograph No. 1, British Institute of Metals

Element Atomic No.	Electron Arrangement in Free Atoms	Crystal Structure (note a)	Axial Ratio c ÷ a	Coordination No.	Lattice Constant a	Lattice Constant c	Interatomic Distance d_1	Interatomic Distance d_2	Atomic Diameter (Coordination No. 12)
Group VII A in Periodic Sequence									
25 Manganese	(2)(8)(13)2	α = Cubic (note b)	—	—	8.894	—	—	—	—
		β = Cubic (note c)		12	6.300	—	—	—	—
43 Masurium	(2)(8)(18)(14)1	—	—	—	—	—	—	—	—
75 Rhenium	(2)(8)(18)(32)(13)2	⬡	1.614$_8$		2.755$_3$	4.449$_3$	2.734$_9$	2.755$_3$	2.75
Group VII B									
9 Fluorine	(2)7	—	—	—	—	—	—	—	—
17 Chlorine	(2)(8)7	—	—	—	—	—	—	—	—
35 Bromine	(2)(8)(18)7	—	—	—	—	—	—	—	—
53 Iodine	(2)(8)(18)(18)7	▯	a÷b÷c=1÷1.51÷2.04		4.795	9.780 b=7.255	2.70	(note d)	—
85 Alabamine	(2)(8)(18)(32)(18)7	—	—	—	—	—	—	—	—
Group VIII in Periodic Sequence									
26 Iron	(2)(8)(14)2	α = ⧈	—	—	2.86$_{10}$	—	2.47$_7$	—	—
		γ = ⊡	—	—	3.64 ← at 900°C.		2.58$_0$	—	2.52
27 Cobalt	(2)(8)(15)2	α = ⬡	1.624	—	2.50$_7$	4.07$_2$	2.49$_9$	2.50$_7$	2.50
		β = ⊡	—	—	3.54$_5$	—	2.50$_7$	—	2.50$_7$
28 Nickel	(2)(8)(16)2	α = ⬡	1.64	—	2.49	4.08	2.49	2.49	2.49
		β = ⊡	—	—	3.51$_{70}$	—	2.48$_{69}$	—	2.48$_7$
44 Ruthenium	(2)(8)(18)(15)1	⬡	1.585	—	2.69$_5$	4.27$_3$	2.64$_3$	2.69$_5$	2.67
45 Rhodium	(2)(8)(18)(16)1	⊡	—	—	3.79$_{55}$	—	2.68$_{38}$	—	2.684
46 Palladium	(2)(8)(18)(18)-	⊡	—	—	3.88$_{24}$	—	2.74$_{53}$	—	2.745
76 Osmium	(2)(8)(18)(32)(14)2	⬡	1.578	—	2.730	4.309	2.669	2.730	2.70
77 Iridium	(2)(8)(18)(32)(15)2	⊡	—	—	3.83$_{12}$	—	2.70$_{91}$	—	2.709
78 Platinum	(2)(8)(18)(32)(16)2	⊡	—	—	3.9$_{158}$	—	2.76$_{89}$	—	2.769
Rare Earth Group									
58 Cerium	(2)(8)(18)(19)(9)2	α = ⬡	1.62	6,6	3.65	5.91	3.63	3.65	3.64
		β = ⊡	—	12	5.14$_3$	—	3.63$_7$	—	3.63$_7$
59 Praseodymium	(2)(8)(18)(20)(9)2	⬡	1.620	6,6	3.65$_7$	5.924	3.63$_6$	3.65$_7$	3.65
60 Neodymium	(2)(8)(18)(21)(9)2	⬡	1.608	6,6	3.65$_7$	5.88	3.61$_9$	3.65$_7$	3.64
68 Erbium	(2)(8)(18)(29)(9)2	⬡	1.63	6,6	3.74	6.09	3.73	3.74	3.73

Notes: (a) ⧈ is body-centered cubic; ⊡ is face-centered cubic; ⬡ is close-packed hexagonal; ▯ is orthorhombic

(b) Approximates ⧈ where each lattice point is a cluster of 29 atoms; 1 type X, 4 type A, 12 type D_2 and 12 type D_1. The X atoms occupy the largest volume and the D_2 the smallest. Interatomic distances of neighboring atoms are as follows:

X atoms have 12 D_2 at 2.71
4 A at 2.82

A atoms have 1 X at 2.82
3 D_1 at 2.49 and 3 at 2.96
3 D_2 at 2.69 and 3 at 2.89

D_2 atoms have 1 X at 2.71
2 A at 2.69 and 1 at 2.89
1 D_2 at 2.24 and 2 at 2.38
1 D_1 at 2.45, 2 at 2.51 and 2 at 2.66

D_1 atoms have 1 A at 2.49 and 1 at 2.96
1 D_2 at 2.45, 2 at 2.51 and 2 at 2.66
6 D_1 at 2.67

(c) Complicated structure with 20 atoms of two kinds in unit cell.
Each atom of the first kind has
3 neighbors at 2.365
3 " " 2.530
3 " " 2.671
3 " " 2.675
Each atom of the second kind has
2 neighbors at 2.530
2 " " 2.615
4 " " 2.659
2 " " 2.671
2 " " 2.675

(d) Atoms arranged in pairs so that each one has one close neighbor at 2.70. Data from A.S.M. Metals Handbook.

Shears off

NEEDLESS COSTS *and* NEEDLESS WEIGHT

The trouble with costs is you can't tell how much is *needless* until there's a basis for comparison. But here's one that ought to be interesting to every user of tool steels. The shear blade pictured above operating on hard alloy steel stock was formerly made of carbon tool steel. After cutting 200 to 500 pieces, however, the blades regularly became spalled or broke out at the edges. But after the Henry Disston Steel Works furnished blades made of their "827" medium carbon Nickel-chromium steel, the average service life jumped to 3,000 to 6,000 cuts between grinds with no spalling or breakage. Nickel steel not only sheared more parts but sheared off needless cost.

Here at the right we have a case where the cost of handling material was appreciably cut by reducing the weight of equipment, thereby increasing the pay load. By using "Yoloy", a high tensile Nickel-copper alloy steel produced by the Youngstown Sheet and Tube Co., Youngstown, Ohio, in the construction of this large breakdown coal bucket, its pay load capacity was increased from 6 to 7 tons without increasing its gross weight.

NICKEL
ALLOY STEELS

You can't help but have respect for the thrift of transportation equipment that delivers a *million miles* of service. At least that much mileage is given by the railroad coach journal bearing pictured at the left, a type that is used by 24 leading railway lines and manufactured by The Fafnir Bearing Co., New Britain, Conn. Among the reasons are the inner race (A) made of shock-resisting Nickel-molybdenum carburizing steel and the housing bore (B) made of wear-resisting Nickel Cast Iron.

We invite consultation on the many ways in which the Nickel Alloy Steels will help to reduce operating and maintenance costs.

THE INTERNATIONAL NICKEL COMPANY, INC., NEW YORK, N.Y.

INTERNAL FISSURES INDUCED IN RAILS BY SOAKING IN HYDROGEN

From the Third Progress Report
Investigation of Fissures in Rails
Directed by H. F. Moore
University of Illinois

READERS of METAL PROGRESS have been kept informed of the investigation of fissures in rails, sponsored by the American Railway Engineering Association. Summaries of the first and second reports have been printed in issues dated November 1935 and July 1936. During the third year an extensive study of the wheel loads occurring in a portion of Santa Fe railroad track carrying heavy freight tonnage, added to the information already gathered, supported an earlier conclusion that while irregularities in the car wheels were chiefly responsible, stiffness of the track is a contributing factor to high wheel loads in inducing dangerously high stresses in the rails. This matter of actual track stresses is being given intensive study because it is believed that the direct action of high wheel loads *starts* an internal fissure, and bending stresses in the rail play an important part in subsequent *growth*.

Additional work also confirms the tentative conclusion of the test party reported last July that the slow bend test (head down) is distinctly superior to the present standard drop test (either head up or head down) as a detector of shatter cracks in rail heads. Furthermore, the slow bend gives an opportunity to estimate stresses during the test and also the ultimate strength at fracture.

Since it is known that unsound rails sometimes come from the mill, further attempts were made with a microphone to detect cracking during cooling. Even when eliminating outside noises heard in a cooling rail by comparing those from a cold dummy rail, both suspended from sound-damping blocks of rubber, the noises produced by scale popping off the cooling rail made this test unreliable. It is therefore concluded that the microphone alone does not give much promise of usefulness. More promising results have been obtained from a combined test using acoustics and electrically induced vibration; a critical study of this is under way.

Shatter Cracks Formed by Hydrogen

[An editorial review of the efforts made by various steel mills to insure sound rails was printed in METAL PROGRESS in July 1936. One school of thought insists on slow and controlled cooling almost stone cold — precisely the practice recommended to avoid flakes in large forgings. Professor Moore's party therefore gave some attention to the artificial production of shatter cracks in rails known to be sound.]

During the past year a considerable amount of work has been reported tending to show that

flakes, which seem to be about the same thing as shatter cracks, are caused by the liberation of hydrogen at low temperatures, this hydrogen having previously been in solution in the hot steel. Some tests were therefore made to determine whether shatter cracks can be produced in rail steel heated in an atmosphere of hydrogen.

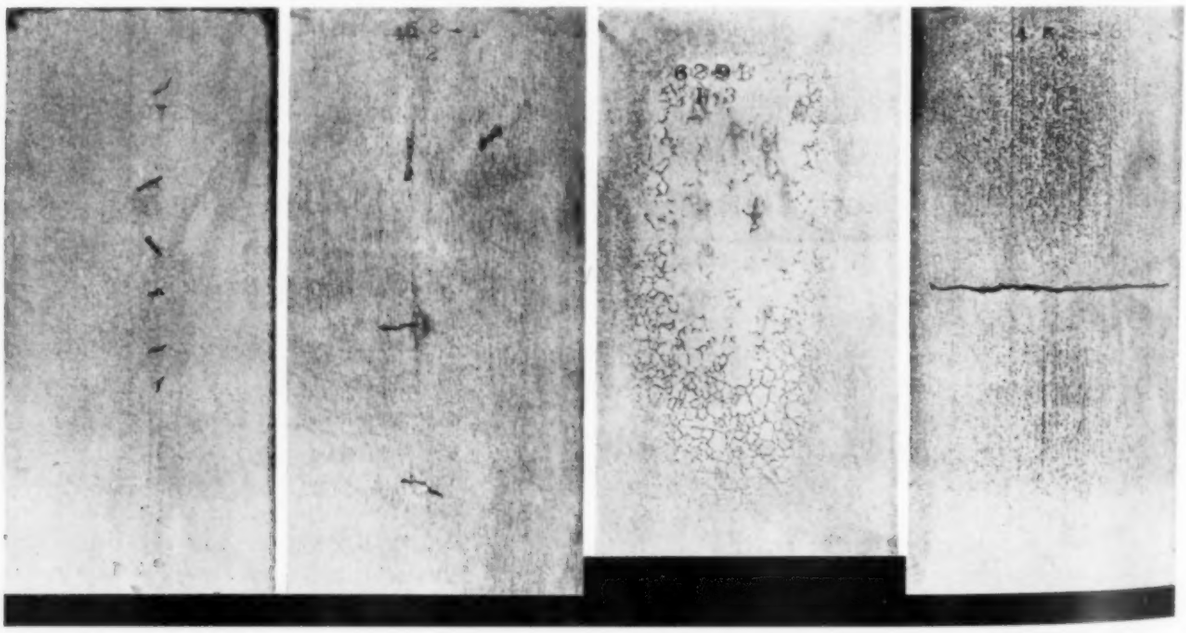
Seven tests were made on six-inch pieces, taken from three different rails known to be free from shatter cracks. In five of the tests such cracks were formed and discovered by longitudinal slices after being etched. (It must be remembered that this method does not record *all* of the cracks in the rail, but only those found on the particular section chosen.) The accompanying photograph shows four of the specimens in which cracks were produced in rails originally free from shatter cracks, and a brief description of the heat treatment is given in the caption below the cut.

These experiments, together with the results reported from Europe, offer reasonable proof that hydrogen can be one factor which produces shatter cracks or flakes in steel, but these tests do not justify the conclusion that hydrogen is the *only* factor which can produce these cracks. The logical explanation is based on the presumption that hydrogen liberated during the cooling of steel finds difficulty in diffusing through the metal as the temperature is lowered and becomes trapped in the interior, probably collecting in the tiny spaces around inclusions and in any other small voids. The pressures built up in these small spaces may become very high and are distributed over minute areas so that the stress may exceed the tensile strength of steel, whereupon a small crack develops and relieves the pressure.

When hydrogen exists in steel, its most likely source seems to be water vapor and steam which are formed by the combustion of fuel or sometimes blown into the openhearth furnace and the soaking pit. Steam at high temperature is an active oxidizing agent, and the hydrogen liberated by the reaction is fairly soluble in molten steel or even solid steel at forging temperatures.

Hardened Ends

A considerable portion of the third report has to do with studies of rails which have had their ends hardened in the rail mill by one of five processes.



Shatter Cracks Produced in Sound Rails by Heating in Hydrogen at 2200 to 2300° F.

Horizontal slices cut from heads, etched in hot HCl. Photographed half natural size. First at left is 110-lb. rail cooled in air. Next is 110-lb. rail heated to incipient fusion at edges, cooled in air; these cracks are not considered to be typical shatter cracks. Next is 130-lb. rail cooled in air. Last, at right, is 130-lb. rail quenched from 1500° F.; many small cracks were found on both sides of the large internal burst, but few within ½ in.

In process No. 1 the rail is cooled on the hot bed and the ends are reheated by induction currents to 1520° F. in 80 sec., after which it is water quenched by an automatically regulated flow of water for 30 sec.

In the second process the rails were hot-bed cooled and box cooled. The end of the rail head was then reheated by a gas burner to approximately 1550° F. in 3 min., and quenched with a jet of compressed air for 3 min.

In the third process the rails after leaving the hot saws are cooled to about 1500° F. and the ends then quenched in a water spray for 30 to 35 sec., depending upon carbon content and rail section. When the body of the rail has cooled to 1000° F. a small cover about 6 in. long is placed over the rail head at the end.

In the fourth process the rail is cooled on the hot-bed below the critical temperature and the ends then rapidly reheated to about 1500° F. and quenched in the water spray as in the third process. A small annealing cover is also used.

In the fifth process the cold rail is cleaned of scale and the end reheated in a portable gas-fired furnace until the top of the head reaches 1500 to 1600° F. This takes 4 min. The furnace is then removed and a quencher immediately placed on the hot rail, the quenching medium being either cold air at 70 lb. pressure or air with some steam (in the event the steel is somewhat low in carbon).

All these processes give a rather deep penetration of hardness into the head of the rail, in extreme cases actually extending to the web. Other processes of flame hardening are used after the rail is laid in track to produce a much shallower zone of hardness, which condition is held by some to be more desirable. (For one field process see an article by M. D. Bowen in METAL PROGRESS, April 1931.) Hardness surveys on a section through these deeply hardened ends indicate that the hardened zones range from Rockwell C-31 to C-49 (279 to 441 Brinell). In the unhardened rail head the hardness range is from C-23 to C-31 (207 to 279 Brinell). Metallographic examination indicated a quite evident grain refinement in the hardened zone. In one or two cases a localized structure of martensite was found, but it seems likely that this was due to accidental irregularities occurring in heating or quenching.

Comparative test specimens, as might be expected, showed higher strength values in the hardened material than in the unhardened steel nearby. "The surprising result was found that for the end-hardened rails so far tested, not only are the tensile strength and the fatigue strength increased in the hardened part, but also the ductility as shown by elongation and reduction of area, and the toughness as shown by the impact test." This was explained by referring to the finer grain structure in the heat treated material and is regarded as "a striking illustration of the possibility of increasing the strength of high carbon steel without reduction of ductility by proper heat treatment." [These same conditions are noted in an article in METAL PROGRESS concerning the manufacture of crossings and special work of heat treated rail, by Edwin W. Goodaire in March 1936. It should be remembered that rail steel, cooled on the hot-bed, cools slowly enough to transform directly into pearlite wherein the carbide is in laminated platelets, whereas the same steel after subsequent quenching and tempering has most of the carbide in finely dispersed particles (sorbite). Hence the simultaneous improvement of strength, ductility, and toughness.]

Results of Tests of Specimens From Ends of Heads of Rails

	Hardening Process No. 1		Hardening Process No. 2	
	Unhardened	Hardened	Unhardened	Hardened
Weight of rail	131 lb. per yd.	131 lb. per yd.	112 lb. per yd.	112 lb. per yd.
Elongation in 4 diameters	8%	14%	12%	16%
Reduction of area	14%	40%	22%	41%
Izod-Olsen test (notched)	1.7 ft-lb.	4.1 ft-lb.	1.9 ft-lb.	2.4 ft-lb.
Charpy test (unnotched)	120 ft-lb.	Unbroken at 225 ft-lb.	120 ft-lb.	Unbroken at 225 ft-lb.
Tensile strength	136,000 psi.	165,000 psi.	123,000 psi.	142,000 psi.
Fatigue limit	66,000 psi.	94,000 psi.	65,000 psi.	82,000 psi.
Hardness				
Brinell	250	350	240	310
Rockwell	C-30	C-40	C-26	C-35

CORRESPONDENCE AND FOREIGN LETTERS

Mechanism of "Peeling" of a Zinc Coating

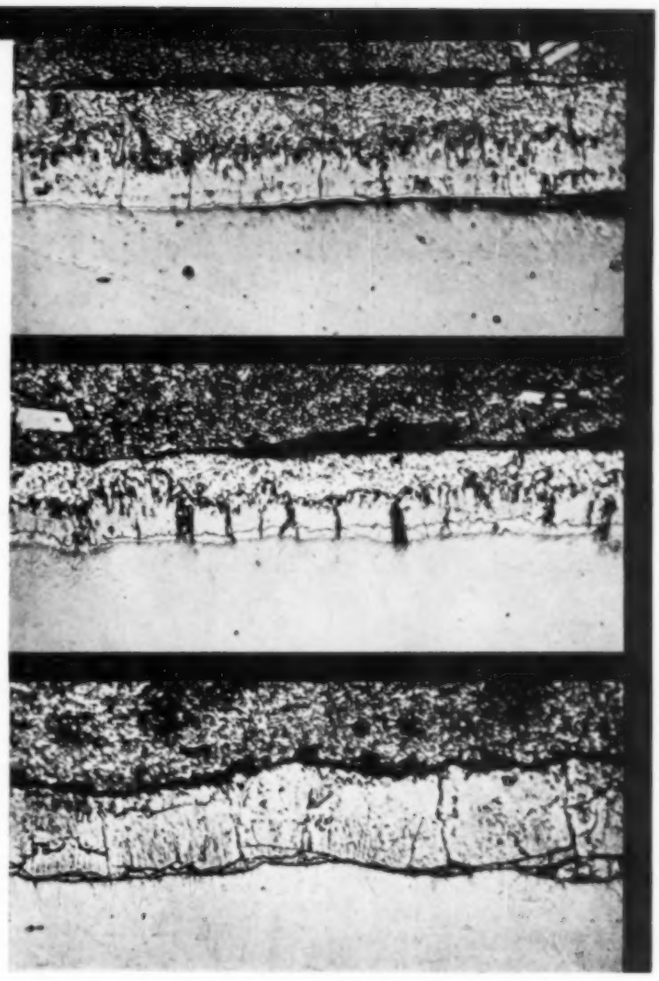
Special Letter to METAL PROGRESS
by GEORGE F. COMSTOCK
Metallurgist, Titanium Alloy Mfg. Co.

NIAGARA FALLS, N. Y. — J. L. Schueler's paper on "Galvanized and Galvannealed Sheets" in the May METAL PROGRESS was interesting, but I believe incorrect in one or two statements. These are that the galvannealing process causes the zinc coating to become "more malleable," and that heavy zinc coatings are "inherently brittle." Also the photomicrograph on page 502 is not typical of any galvannealed coating that I have seen, although I must admit that my experience was obtained several years ago and present practice may be different. At that time, however, a rather careful investigation of zinc coatings on steel and their peeling or "brittleness" was made, and I hope that these results of that work may still be of some interest to readers in this connection.

It is well known that a normal hot-dipped zinc coating on steel consists of three layers; first an inner alloy layer next to the steel, continuous and usually comparatively thin and uniform; second an outer alloy layer, often thicker and more irregular; and third the outside layer of zinc. The inner alloy approaches Fe_3Zn_{10} in composition, and the outer one $FeZn_7$. All galvannealed coatings that I have seen are uniform, consisting of but a single layer, probably Fe_3Zn_{10}, since there is of course an excess of iron in contact with the alloys during the annealing of a coating on steel. Now in view of what is known regarding the comparative brittleness of intermetallic compounds, does it not seem rather strange to claim that a coating of this compound Fe_3Zn_{10} is more malleable than a coating composed partly of relatively pure and uncombined zinc?

Mr. Schueler's statements regarding the peeling of zinc coatings are quite correct. Thick coatings made by the ordinary hot-dip process on low carbon steel often peel badly when the coated steel is bent. This does not mean, however, that the coating is brittle but merely that the bond with the steel is weaker than the lengthwise strength of the coating itself, so that when the steel is bent the coating tends to remain straight rather than bend with the steel. This causes the two to separate, and large flakes of the coating become free, or "peel."

The top photomicrograph on the next page is submitted to illustrate the fact that the separation occurs between the inner layer of the coating and the steel. The galvanized steel specimen photographed for that view was bent back and forth before being mounted for sectioning, polishing and etching. If this coating had been brittle, and not comparatively tough



Lengthwise section of a galvanized soft steel wire after bending and straightening, etched with 1 drop HNO_3 in 10 c.c. alcohol, and magnified 400 diameters. The lowest strip is the steel base, and the topmost is soft metal in which the specimen was mounted. In between is the coating, with two alloy layers and a layer of zinc. Separation is shown between the steel and inner alloy layer.

Lengthwise section of a non-peeling galvanized soft steel wire, bent, etched and magnified as above and showing layers of the same character. Although transverse cracks of the alloy layers are prominent there is no separation of the coating from the steel base.

Lengthwise section of a galvannealed coating, bent, etched and magnified in the same way, showing the steel below, the coating in the middle, and the mounting at the top. This coating is homogeneous but rather badly cracked.

Fractures in Zinc Coatings on Wire Due to Bending

due to the free zinc layer, it would have broken up crosswise into a lot of little pieces, instead of peeling off in a large flake.

A non-peeling hot-dipped zinc coating, after bending as above, is shown in the second view. Here crosswise cracks can be seen in the alloy layers, while the outer zinc coating, being tough and malleable, did not crack — and it is also noted that there is no separation between the coating and the steel base, which means no peeling. The bond here was stronger than in the first case, but the alloy layers were at least as brittle or seemingly even more so.

Finally a galvannealed coating, after similar treatment, is shown in the third photo. This coating is all one alloy constituent, and is seen to be badly cracked, though not separated from the steel base. This alloy is, as would be expected, just as brittle as the alloy in the second view, but the bond with the steel is also strong, and the expansion of the outer layer (or coating) due to bending is taken care of by transverse cracks, the lengthwise strength against cracking being in this sample less than the adhesion of the cracked portions to the steel. Of course there are some lengthwise cracks too, which were enlarged by etching, but the cracked portions must be held together somehow, possibly by interlocking, since it is true that galvannealed coatings resist peeling in a remarkable way, considering their inherent brittleness.

I trust that these illustrations may give a clearer idea than Mr. Schueler did of the difference in properties of these kinds of zinc coatings, and of the actual mechanism of "peeling". There are certain kinds of zinc coatings, containing other alloys than iron, that fly off in the form of fine powder on bending, and these are truly brittle, but the ordinary thick hot-dipped zinc coatings on low carbon steel do not behave in that way and are not *brittle*, even though they may peel off when the coated steel is bent.

GEORGE F. COMSTOCK

Divergence of European Standards

Special letter to METAL PROGRESS by
FEDERICO GIOLITTI
Consulting Metallurgical Engineer

TURIN, *Italy* — It is generally admitted that the widely different points of view of the various European countries on a great number of political, economical, social — and even technical — problems will be a serious hindrance to the formation of the "United States of Europe."

Not all those problems have the same importance, and it will be easily admitted that many of them (such as, for instance, the problem of disarmament) are certainly more important, and perhaps more difficult of solution than the problem of fixing the best depth of notch for impact test bars! Nevertheless the useless attempts made during many years to find a "European" solution of this problem may give, perhaps, an approximate idea of the difficulty of solving some of the others.

In previous letters I had the opportunity of noting the extensive discussions that have taken place during past years, in many international congresses, leading toward the European standardization of test bars. Yet the present situation is well stated in the first sentence of a recent paper by S. Menghi (*La Metallurgia Italiana*, August 1936), which runs as follows:

> "After the success of the efforts in view of the international standardization (at least for continental Europe) of the dimensions of impact test bars (10 x 10 x 55 mm.), the question of depth of notch is still under discussion after many years, and an agreement is not yet in view."

In fact the test bar of standard dimensions has been adopted now for many years by all European continental countries, but practically each important one has adopted a different depth for the notch: 3 mm. in Germany; 2 mm. in Italy; and 5 mm. in France. A great deal of experimental research is carried on in each country to prove the superiority of the special notch adopted! These experimental data have been — and will probably be for many years to come — the subject of long and detailed discussions in the international congresses, with the only practical result of rendering more and more difficult the attainment of a final international standard.

Though this last statement may seem at first sight a paradox, it exactly corresponds to the truth, as Mr. Menghi justly remarks in the above quoted paper. It is evident that since the impact test has been generalized in the field of industrial products, enormous amounts of data have been and are being accumulated, and the difficulty of changing their basis of reference — as would be necessary if the type of test bar should be changed — will increase in direct ratio with the increasing amount of such data.

The above remarks may seem trivial to an American reader, who cannot now realize the difficulties associated with the multiplicity of neighboring and technically advanced nations. It is possible that the future of pan-American projects will cause such troubles as those connected with the standardization of notches to become much more familiar to metallurgists in the United States of America.

FEDERICO GIOLITTI

Directional Properties in Brass Strip

A Correction by
J. D. JEVONS
Joseph Lucas Research Laboratories

BIRMINGHAM, *England* — In abstracting my discussion of Dr. Cook's paper on the above subject you have attributed to me statements which I did not make and which are incorrect. [Editor's Note — The abstract was made from a report in a British periodical, and not from the version issued by the Institute of Metals, which was not then available.]

On page 676, line 9 of METAL PROGRESS for June, the following sentence occurs:

> "It is particularly interesting to observe that the splits (due to directional properties) always occur at approximately 45° to the direction of rolling."

This statement, expressed by you as a general one, is untrue; with rolled brass sheet, for example, *maximum* ductility usually occurs at 45° to the direction of rolling, and splits would therefore tend to occur at 0° and 90° to this direction, *not* at 45°. In its proper context the statement described steel sheet processed (as it often is) so that *minimum* ductility occurred at 45° to the direction of rolling.

The next sentence, "It is hard to convince a user that this (splitting at 45°) is due to defects in his forming tools or some other shop condi-

tion," does not represent any of my remarks. Indeed, I had just shown that this splitting was *not* due to tools or shop conditions but to excessive directionality in the sheet.

In the last paragraph on the same page you say: "The length of the tear so made, while doubtless representing the combined effect of more than one property of the sheet, will be approximately equal in sheets with minimum directional differences, and markedly various in sheets that have distinct directional properties." I did not say or imply that tears of equal length can be obtained in commercial practice. I have never tested a sample in which the tear length values obtained at 0° and 90° to the direction of rolling were even nearly equal.

In describing the details of the tear length test you give the width of the flap as ¼ in. The standard width in this country and on the Continent is 1 cm., the value I actually gave. If your readers start experimenting with ¼-in. flaps their results will not be comparable with those of their friends across the Atlantic, and confusion may arise.

J. D. JEVONS

Free-Cutting Aluminum Alloys

Special letter to METAL PROGRESS by
HANS DIERGARTEN
Metallurgist, SKF Ball Bearing Co.

SCHWEINFURT, *Germany* — Special significance has been attached in recent years to the free-cutting aluminum alloys, which are at present of considerable interest.

In the past the machining of high strength aluminum alloys has encountered economic considerations leaving much to be desired — for example because of high tool wear, difficulties caused by long chips, quality of results in thread cutting, surface conditions, and other requirements. The viewpoint that led to the introduction of free-cutting steels and brasses was therefore applied to the aluminum alloys — that is, that a special free-cutting aluminum alloy should be created.

In the years 1931 and 1932 M. Hansen and W. Blumenthal found that the addition of lead to pure aluminum resulted in the shortening of the chips formed in machining (*Zeitschrift für Metallwirtschaft*, vol. 10, 1931, p. 925 and vol. 11, 1932, page 671). These investigations were not, however, intensively pursued.

The development of the free-cutting alloys in America and the theory on which this development was based were discussed in METAL PROGRESS by L. W. Kempf and W. A. Dean (July 1935) and by L. W. Kempf and A. Hartwell (December 1936). Among others should be mentioned the alloys containing additions of lead, bismuth, copper, zinc, cadmium, and silicon.

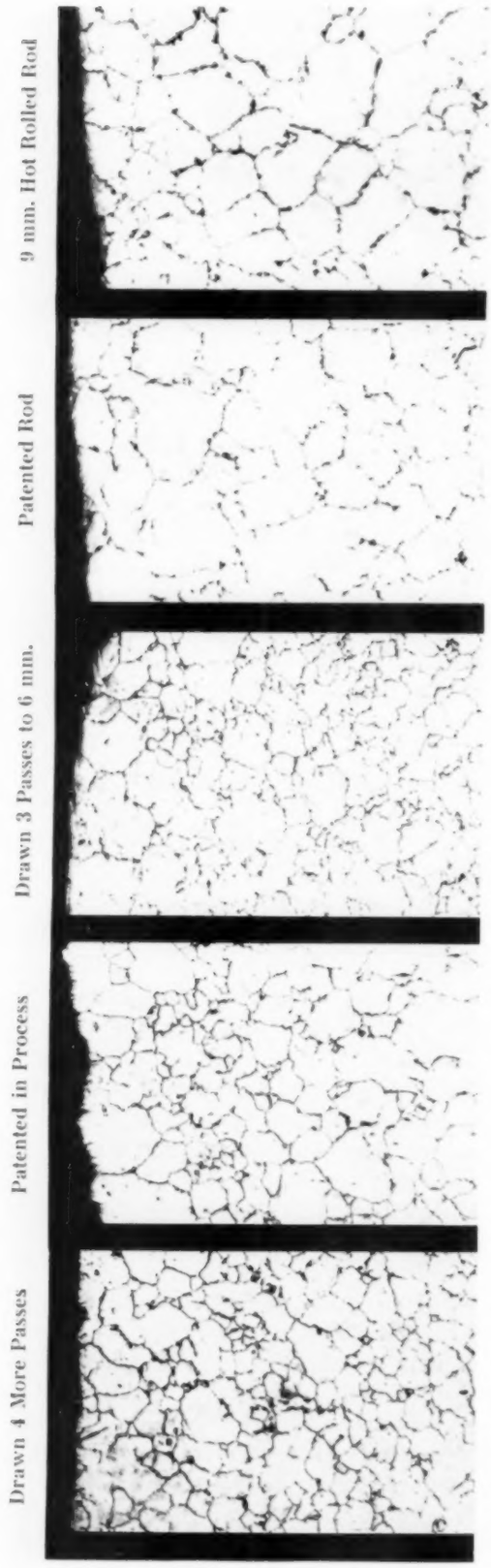
The investigations which have been carried out in Europe, both in practical operation and in various laboratories, are reflected in the publications of H. Bohner ("Free-Cutting Light Metal Alloys Based on the Aluminum-Magnesium Alloys," *Zeitschrift für Metallkunde*, September 1936, page 290); of G. Masing and G. Ritzau ("On the Problem of Free-Cutting Aluminum," *Zeitschrift für Metallkunde*, September 1936, page 293); and of E. Vaders ("Influence of Structure on Chip Formation and Area of Cut in Free-Cutting Alloys With Special Reference to Aluminum Alloys," *Zeitschrift Metallwirtschaft*, August 1936, page 814). Space prevents reprinting the details of these ivestigations here. It will be sufficient to note that Bohner worked on "hydronalium" (aluminum-magnesium alloys), while Masing and Ritzau worked primarily on the alloys containing lead. Both investigators have based their results on photomicrographs and numerical information and have illustrated the practical aspects by photographing various forms of chips made in turning, milling and drilling.

The importance of the free-cutting aluminum alloys induced the Aluminium-Zentrale of Berlin to discuss the subject exhaustively at a meeting of its materials committee in Aachen early this year. The complete papers are collected in a special issue of the publication *Aluminium* for March 1937.

In his lecture entitled "Free-Cutting Light Metal Alloys of the Aluminum-Magnesium Type," H. Bohner summarized in eight points the principal requirements for a free-cutting aluminum alloy:

1. High strength together with good elongation and ductility.
2. Good corrosion resistance.
3. Good pouring qualities without complicated special handling.
4. Ability to take the anodizing treatment readily for surface protection.
5. Ability to economize on aluminum by substituting for a certain percentage of the aluminum content any of the elements available in Germany in large quantities such as magnesium, iron, or silicon. *(Continued on page 180)*

Grain Size After McQuaid-Ehn Carburizing Test of Wire Rope Steel in Various Stages of Manufacture



Influence of Cold Work on Austenitic Grain Size

Special letter to METAL PROGRESS by
ALBERT M. PORTEVIN
Editor, *La Revue de Métallurgie*

PARIS, *France* — We have already pointed out the limitations and conventional significance of grain size as defined by the McQuaid-Ehn cementation test. In the first place, only one point on the geometric surface represented by the function

$$N = \int (\theta_c, t)$$

is obtained; this is the point corresponding to the number of austenitic grains N per unit of section for a heating temperature θ = 1700° F., and a heating time t of 8 hr. A second limitation of this test as characterizing the steel being investigated is that the influence of previous mechanical and heat treatments is neglected, such as refining, cold working, hardening and annealing.

This is derived from the fact that the grain of the steel and its behavior when heated depend primarily on the conditions of manufacture and secondarily on the treatment, or conditions of transformation. Therefore the grain of the steel — or, more precisely, its method of growth — may be considered to be somewhat characteristic of the ingot, although, as shown by Epstein, Nead, and Washburn, there may be no noticeable difference after rolling between a so-called coarse-grained steel and a fine-grained steel, yet the difference becomes visible after the carburizing test. It would, however, be wrong to neglect entirely the conditions of transformation and treatment. Grossmann's experiments (*Transactions* A. S. M., Vol. 22, page 861, 1934) have shown the influence of previous heat treatment and forging.

The following steps in a recent experiment clearly indicate the effect of cold work:

1. Hard steels (0.85% carbon and 0.5% manganese) for high strength wire rope were selected in the form of hot rolled rods 9 mm. diameter.

2. A quench into a lead bath so as to obtain very fine troostite or pearlite. (For this purpose rapid cooling must lead to the temperature at which the Ar′ transformation occurs in the minimum of time — that is, only a few seconds.) This is provided by a quick dip into a lead bath at 780° F. of a coarse-grained steel heated at 1690° F.

3. Drawing through dies, reducing the diameter from 9 mm. to 6 mm. after three passes.

4. A repetition of the quench into a lead bath, as at the start.

5. Subsequent drawing, reducing the diameter to 2 mm. after four passes.

The corresponding photomicrographs — all at 100 diameters — show the condition of the steel in each of these stages after the McQuaid-Ehn cementation test

and etching the polished steel with sodium picrate.

It is obvious that the number of grains per unit area varies in the ratio of 1 to more than 5 for the same steel submitted to the same test but following different mechanical treatments.

Refining by hot forging also affects the grain growth behavior; thus, a given steel forged into small bars (for instance, 8 mm. in diameter) will show grain growth at a lower temperature than though it were forged into big bars (for instance, 20 mm. or more in diameter). This is not due to the dimension of the bars, for the same observation can be made if test pieces of the same diameter are machined from the big bar and the small one.

Thus there is good reason to qualify the grain size and hardening power of a steel by testing samples submitted to various hot rolling, hot forging or cold working treatments — for instance, bars in which the ratio of section to perimeter is 2, 3 and 5.

ALBERT PORTEVIN

Delray Turbine Blades

A Correction by
W. J. DAWSON
Director, Hadfields Ltd.

SHEFFIELD, *England* — In the article entitled "Pipe, Valves and Turbines for High Temperature Steam" by R. M. Van Duzer, Jr., appearing in the June issue, it is stated that the first stage buckets of the turbine of the second experimental installation in Delray Power House No. 3 were made from "Midvaloy ATV-1."

May we be allowed to correct this by saying that these particular buckets were in fact produced from "Hecla/ATV" steel manufactured by ourselves. This was correctly stated by Thompson and Van Duzer in an earlier article on "High Temperature Steam Experience at Detroit" in *Combustion* for November 1933.

In asking you to publish this correction, may we explain that our friends, The Midvale Co., possess the rights of manufacture in the United States of the well-known "ATV" steel. As, however, the Delray turbine was constructed in this country by the British Thomson Houston Co., the provision of the "ATV" blading fell to us as owning the similar rights for the British Empire.

W. J. DAWSON

Voids in Graphitic Steels

Comment by
M. L. SAMUELS
Battelle Memorial Institute

COLUMBUS, *Ohio* — In the very interesting and instructive paper on "Developments in Graphitic Steel for Tools & Dies" by Messrs. Bonte and Fleischmann which appeared in the April 1937 number of METAL PROGRESS the statement is made that after graphite precipitation, absorption during a subsequent heat treatment leaves voids or microscopic pockets which act as oil retainers. This statement is somewhat puzzling and is contrary to results obtained at Battelle Memorial Institute in some work for Bethlehem Steel Co. on a comparable steel.

The left hand figure on page 168 shows nodules of graphite after a slow cooling treatment which produces a completely malleableized structure. The steel was then reheated to 1700° F., quenched in oil and drawn at 900° F., and the right hand figure shows graphite nodules after this treatment.

The drawing temperature is too low for any graphitization to take place. The graphite in the second view therefore survived the hardening treatment. Further evidence to this effect is that graphite nodules have been observed in the quenched condition before any drawing treatment was applied.

A mechanism whereby the graphite would be taken into solution, leaving a void, is difficult to comprehend. It would seem that when a material such as that shown in the first figure is heated above the transformation range the graphite would go into solution up to its limit of solubility as controlled by the composition of the steel and the temperature. Supposing this solubility to be higher than the total carbon content of the steel, how would the microscopic pockets be produced?

It is thought that the outer portion of the graphite nodules and the iron dissolve into each other forming a zone of carbon-rich austenite. Diffusion from this zone into the iron regions further away from the graphite would lower its carbon content so that further solution between the graphite and its adjacent layer of austenite could take place. In this manner the austenite advance would reach the center of the nodule at the instant the last particle of remaining graphite dissolved.

If a void is formed it would seem that the

carbon atoms at the surfaces of the nodule going into the iron lattices would leave a space between the nodule remnant and the iron. How, then, would the remaining or central portion of the graphite particle jump through this space and enter the iron?

In the production of "white heart" malleable castings a highly oxidizing condition removes the carbon from the surfaces. This surface, or carbon-poor layer, takes up carbon from the richer zones back of it and then in turn gives this carbon up at the surface through oxidation. This action is repeated until the graphite from the center is removed, *but*, such castings do not contain voids. Is not this mechanism of solution and diffusion the same as in the case reported by Bonte and Fleischmann?

As to the practical side of the question, the small graphite nodules themselves, of course, act as lubricants and prevent scoring and excessive wear probably as effectively as would an oil-retaining pocket. Doubtless, at the wearing surface the graphite particles may be partially torn out and such an oil pocket as described may exist but the conception as to how an actual void can be produced by the solution of the graphite is not very clear from the metallurgical point of view.

M. L. SAMUELS

Reply by Mr. Fleischmann

CANTON, *Ohio* — Mr. Samuels' doubt as to the actual formation of voids or microscopic pockets during the resolution of the graphite in graphitized steel is quite understandable.

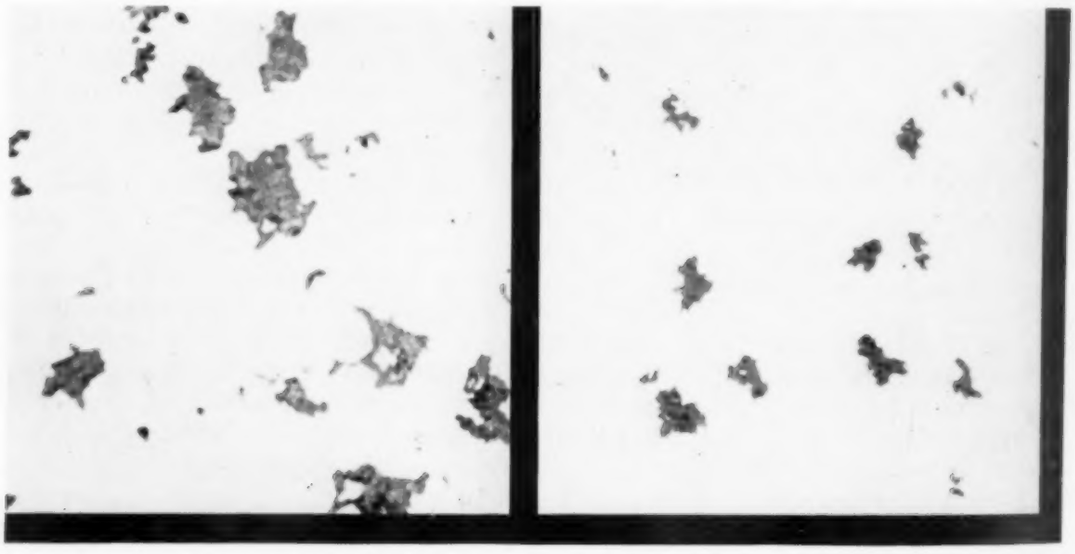
However, the fully annealed and graphitized steel by chemical analysis shows a free carbon content of 1.10% while the same sample after subsequent heat treatment gives a graphite analysis of only 0.68%. Nevertheless, the number and size of the apparent graphite inclusions in both samples remained the same. This fact only can be explained by the assumption that the graphite inclusions in the heat treated specimen are partial voids. This condition actually could be demonstrated under the microscope after the most careful preparation of the microsamples, although the reproductions in the paper as published in METAL PROGRESS do not illustrate this point too well.

We feel that the re-solution of the graphite into the matrix of the steel requires an intermediate phase and that the carbon in the solid state cannot be absorbed by the steel but has to go through a gaseous phase. Oxygen or hydrogen in the steel probably is the carrier of the carbon.

MARTIN FLEISCHMANN

Specimen held at 1500° F. for 1 hr., cooled 100° F. per hr. to 1000° F., removed from furnace and air cooled

After treatment as at left, specimen was reheated to 1700° F., quenched in oil and drawn 1 hr. at 900° F.



Hardening of a Graphitized Steel Does Not Always Produce Voids. (Unetched Micros at 500 Dia.)
Analysis: 1.56% C, 0.38% Mn, 0.008% P, 0.024% S, 1.10% Si

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BELL TELEPHONE SYSTEM

PERSONALS

J. L. Auer has left Crocker Wheeler Electric Mfg. Co. to join R. Hoe & Co., Inc., New York, as assistant works manager.

H. O. Dahlke, U.S.N. has been transferred from duty in the office of the Inspector of Naval Material to the U.S.S. Memphis as senior assistant engineer officer.

Edgar Brooker has resigned from the Standard Oil Co. of California to take a position as metallurgist for the Santa Fe Railway, Test Division, Topeka, Kansas.

Robert H. Heyer, formerly instructor of metallurgy, Purdue University, is now in the Research Department of The American Rolling Mill Co.

E. C. Black has resigned as resident agent for The Midvale Co. in Los Angeles and formed a new company known as Tool Steels, Inc., representing the Tool Steel Division of Henry Disston & Sons, Inc. for the states of California and Arizona.

O. E. Romig, formerly contact representative in the sheet and strip division of the Metallurgical Department, has been appointed assistant research engineer of the Pittsburgh District Research Laboratory, Carnegie-Illinois Steel Corp.

Gosta Lofberg has resigned the presidency of S.K.F. Steels, Inc. to become president of the Uddeholm Co. of America, Inc., New York.

Anthony M. Setapen has accepted a position as junior research associate with the American Metal Co., Ltd. at the National Bureau of Standards in Washington, D. C.

S. A. Silberman, Claud S. Gordon Co., Indianapolis, has been appointed electrical engineer of the Indianapolis Zone by the Contest Board of the American Automobile Association.

John A. Shaw is now engineer for Speer Carbon Co.

Frank P. Dahlstrom has joined the staff of the Aetna-Standard Engineering Co., Youngstown, Ohio, as electrical engineer.

R. C. Hudson U.S.N. has relinquished command of the U.S.S. Sands and assumed the duties of executive officer of the Naval Boiler Laboratory at the Navy Yard in Philadelphia.

George E. Smith, superintendent of melting and forging, has also been made general superintendent of The Midvale Co., Philadelphia.

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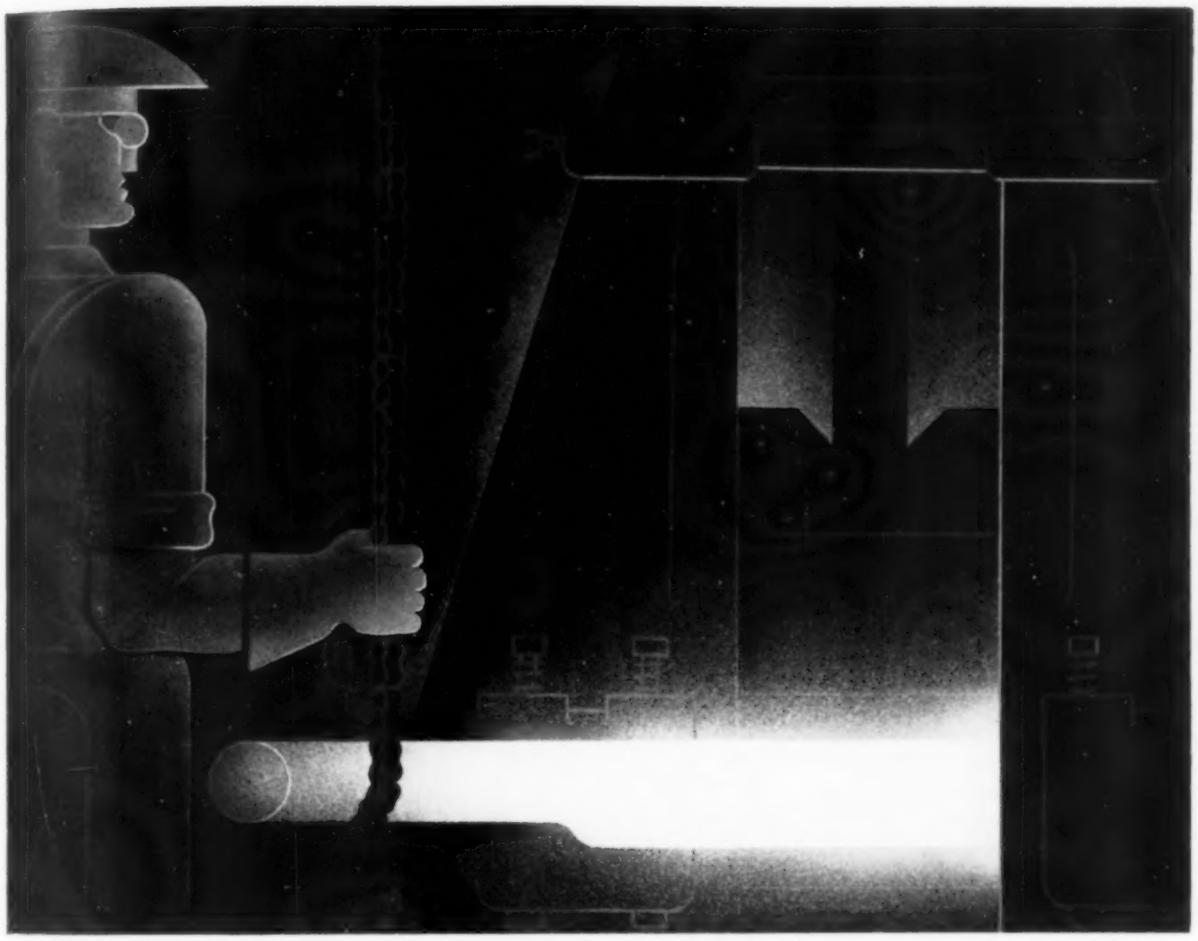

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Our technical book, "Molybdenum," will prove useful to engineers and production heads interested in cost cutting and product improvement. Our monthly news-sheet, "The Moly Matrix," keeps its readers informed on Moly developments. Both sent free on request. Our laboratory is available for the study of special ferrous problems. Climax Molybdenum Co., 500 Fifth Ave., New York.

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MOLY

PERSONALS

W. E. Leuchtenberg, president, Alpha Lux Co., was badly injured in the Hindenberg disaster, but is now well on the road to recovery.

Oren H. Marshall has been promoted from electrical engineer with Rochester Gas & Electric Co. to industrial manager of Erie Lighting Co. and Pennsylvania Electric Co., Erie, Pa.

William Printz has been appointed sales manager for the Eastern Division of the Wheelco Instruments Co. of Chicago.

C. I. Ott has resigned from Landis Tool Co. to be associated with his father in the Ott Machinery Sales Corp., Detroit, as secretary and treasurer.

Harvey T. Harrison has been appointed sales manager for the Duraloy Co., Scottdale, Pa.

H. H. Seabrook, Jr. has been made sales engineer for Yarnall-Waring Co., in the Pittsburgh and West Virginia territory.

J. P. Boore has been appointed assistant general sales manager for The Babcock & Wilcox Tube Co., Beaver Falls, Pa.

Edward W. Ristau has been elected vice-president of Skilsaw, Inc.

Thomas R. Owens has been appointed superintendent of the Gary sheet mills of the Carnegie-Illinois Steel Corp.

E. P. Crawford has been appointed factory representative in the Pennsylvania territory for The Billings and Spencer Co. of Hartford, Conn.

Frank Day, E. J. Ramaley and **Howard L. Womochel** have been appointed to the technical staff of Battelle Memorial Institute, Columbus, Ohio.

C. R. Bottenfield, a mill superintendent for Carnegie-Illinois Steel Corp. at Gary, Ill., has been transferred to Alabama, where he will become superintendent of the tin mill of the Tennessee Coal, Iron and Railroad Co. He is succeeded by **L. S. Dahl**, whose position as superintendent of the cold reduction and annealing departments is taken by **Harry Gude. A. L. Billeter** in turn becomes assistant superintendent of cold reduction, succeeding Mr. Gude, and **Ross O. Laub** is the new assistant superintendent in charge of annealing, Mr. Billeter's former position.

Frank Mooney has been appointed superintendent of the No. 2 Openhearth Plant at the Gary Works of the Carnegie-Illinois Steel Corp.

Don McCormick has been appointed as arc welding consultant for the Kansas City office of Lincoln Electric Co. W. H. Borst and **E. A. Webber** have been appointed to the New York office.

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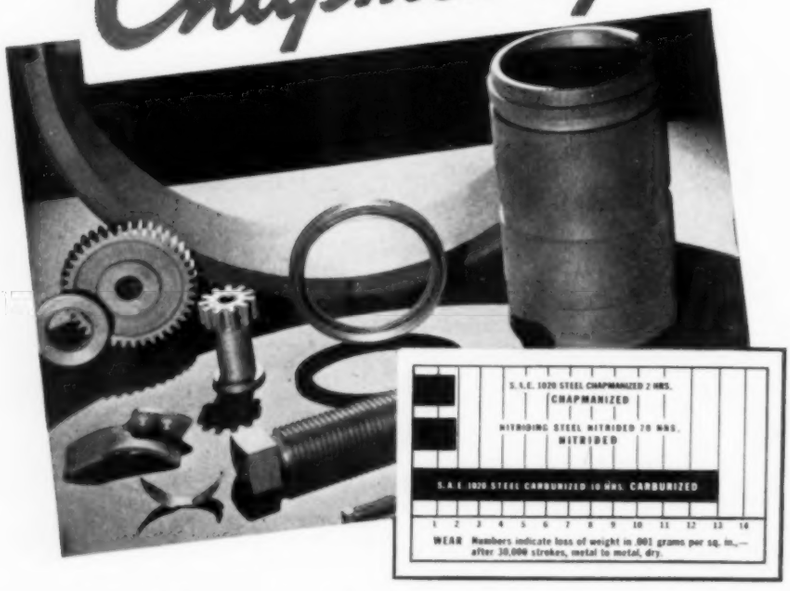
WITH FREE MACHINING STEEL . . .

Chapmanizing


S. A. E. 1020 STEEL CHAPMANIZED 2 HRS.
CHAPMANIZED
NITRIDING STEEL NITRIDED 70 HRS.
NITRIDED
S. A. E. 1020 STEEL CARBURIZED 10 HRS. CARBURIZED
1 2 3 4 5 6 7 8 9 10 11 12 13 14
WEAR Numbers indicate loss of weight in .001 grams per sq. in.— after 30,000 strokes, metal to metal, dry.

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This case can be applied in any depth from .002" to .035" — and it won't chip, flake, corrode, warp, distort. Long pieces can be bent or straightened without fracture or cracking. The process itself is simple . . . the bath retains long-term stability . . . and work is clean, uniform, free from soft spots.

These features have opened new ways to product improvement and lower costs for many concerns where this exclusive, patented process is in daily use. Designers and production men are invited to write for new illustrated book on CHAPMANIZING.

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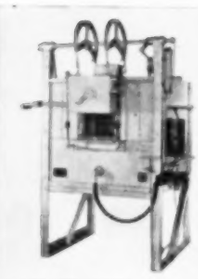

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ELECTRIC CERTAIN CURTAIN FURNACES

CONTROLLED GRAIN SIZE IN STEEL

By T. Swinden and G. R. Bolsover

Abstracted from Journal of the Iron and Steel Institute, 1936, II, p. 457

THE subject of controlled inherent grain size has for many years been a common topic in technical literature emanating particularly from the United States of America. It has not, however, received the serious consideration in Britain which it most certainly merits. The reason, no doubt, is that there are practically no published data of actual experience in Britain, a matter we have attempted to remedy in a three-year research. Undoubtedly in some quarters the subject is still regarded with a strong element of scepticism.

One often hears the statement that "Grain size control has long been practised and understood." In one sense this is true — that is, so far as it relates to the influence of ingot size, casting temperature, amount of reduction in section by hot work and grain refinement by heat treatment. The term "inherent grain size" is, however, something fundamentally different.

It will be impossible to give the data which we have accumulated to prove that certain fundamental properties attach to fine-grained steel, which is usually spoken of in England as "body." If one inquires carefully into the experiences that have led to the statement that one piece of steel has more body than another, it is not unusual to be told that the steel with body is more "foolproof" in heat treatment, and not so liable to deterioration by aging, etc. It would be foolish to claim that fine-grained steel is the simple answer to the production of steel having more body. The fact does remain, however, that, judging by the standards so often employed in comparing steels from this point of view, fine-grained steel undoubtedly possesses some of these characteristics to a far greater degree than coarse-grained steel. In the authors' practice, it is now a matter of routine procedure always to determine the grain size as one of the fundamental factors affecting quality.

We decided to prepare from a number of carbon steel heats (openhearth), ingots of coarse-grained and also of fine-grained steel *from the same cast*. In general, it is found that the effect of fine grain, as against coarse grain, is to reduce slightly the maximum stress and yield stress, to increase *(Continued on p. 178)*

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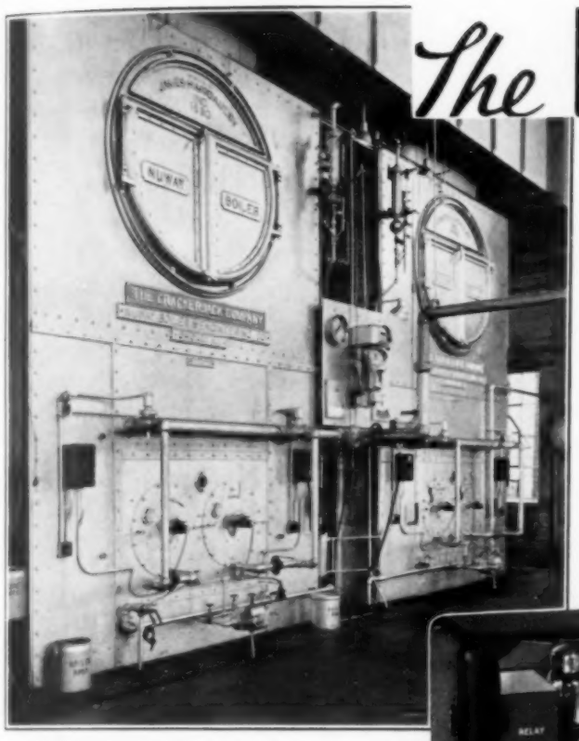

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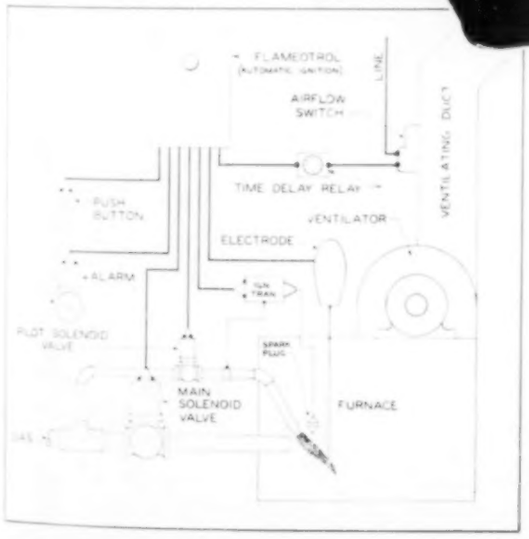
Model 1101
Price $65.00

Adaptability to ordinary fuel combustion and positive protection under every conceivable operating condition was the reason for selecting the Flame-otrol.

Flame failure, for any reason, instantly results in the shut off of the gas supply until the trouble is corrected and furnace, boiler, oven, or heater re-lighted in the normal way.

Below — Flame Protection with Relight, Automatic Electric Ignition, Air flow Switch and Time Delay Relay for Purging.



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The Flame-otrol works with any kind of gas, either high or low in B. T. U. content and with either a rich or a poor flame. Flame fluctuation has no effect. If the electrode is in the top, bottom or side of the flame, the fuel line remains open. Any contact ground of the electrode instantly results in fuel shut-off.

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CONTROLLED GRAIN SIZE IN STEEL

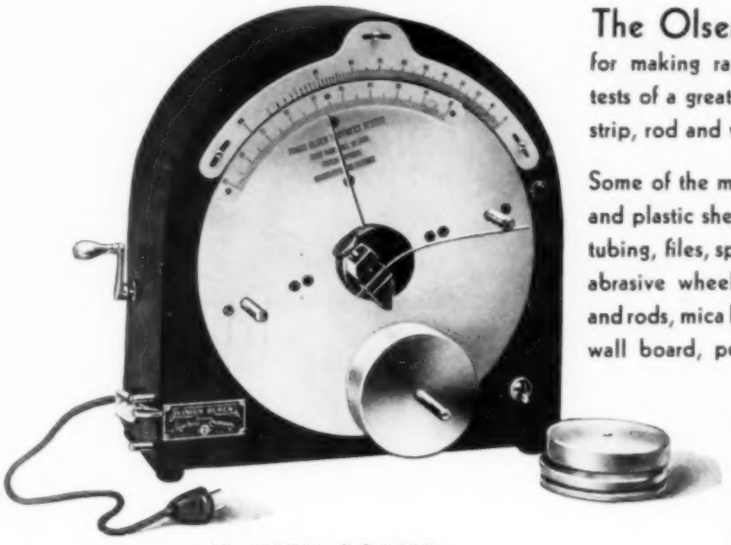
(Continued from p. 174) slightly the ductility as shown by the elongation and reduction of area, and to increase *very considerably* the toughness as shown by the Izod test. Occasional heats of low impact value have always been expected in steels containing about 0.40% carbon, but when these are made fine-grained, adequate toughness is now consistently obtained. With increasing alloy content, and particularly when treating, say, 1⅛-in. round bar, the same necessity for control of grain size does not exist, although even in such steels a decided improvement in the mechanical tests may be obtained.

It has been stated that the beneficial effects of inherent fine grain are offset by the lack of hardness penetration by quenching. However, so far as carbon and alloy structural grades are concerned, apart from the slight general lowering of hardness for a given composition and treatment of the steel, there is no reduced hardness penetration in fine-grained steels and, when judged by impact test results, there is less evidence of mass effect.

Examination was made on a series of casts as to the effect of coarse and fine inherent grain size on the impact value produced by cooling respectively in oil and in the furnace from the tempering heat. While reduced impact values are still obtained on steels normally subject to temper brittleness, the percentage reduction in impact value is lower than on comparable coarse-grained steels. Further, in view of the higher impact values on the fine-grained samples quenched in oil, the specimens slowly cooled after tempering give definitely improved results over those obtained on coarse-grained steels. Quite similar results were found for steels, particularly of the nickel-chromium type, that lose impact value when tempered within the low range of 500 to 750° F.

From a consideration of steel mill practice, the authors do not consider that the "submicroscopic alumina nuclei" theory of grain size control meets the facts, and they doubt whether the later suggestion by McQuaid — that is, the effect of aluminum (beyond that required for deoxidation) on the formation of ferrite from austenite and the coalescence of the carbide — is entirely satisfactory. They incline to the view that the underlying fundamental concerned is the ultimate degree of deoxidation.

STANDARD THROUGH THE YEARS



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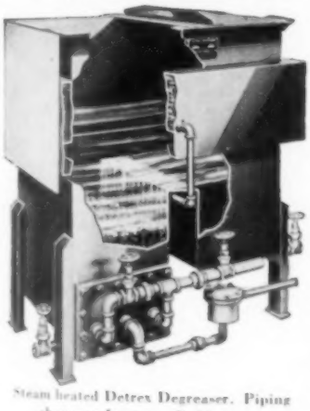

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Provides a clean, warm, dry surface without muss, fuss, or extra drying operations.

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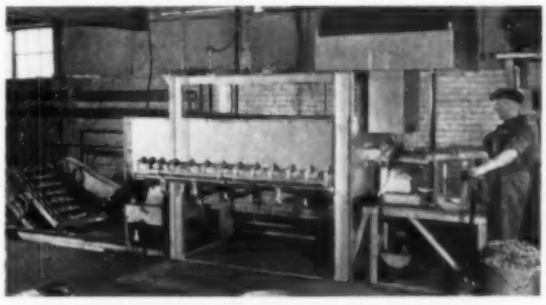

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This old "standby" of screw stocks has been brought up to present-day standards by closely controlled production in B & L mills—insuring uniform quality with physical properties developed to fullest degree in cold drawing.

It is nicely balanced to meet practical screw machine requirements, maintaining good machinable character and preserving dependability in the finished parts. It responds well to surface liquid hardening treatments.

You'll like this better grade of SAE 1112—specify it on your next order.

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FREE CUTTING ALUMINUM

6. On the other hand, avoiding the use of alloying elements which must be imported.

7. No danger of contaminating the new high strength alloys to their detriment through the re-use of the free-cutting alloy shavings.

8. Realization of the desired properties without complicated thermal and mechanical treatment in the manufacture of parts from cast and rolled material.

Another point may be taken from Pagel: Ability to withstand hot working in dies, particularly on parts with large variations in cross-section.

Finally it may be noted that another requirement is similarity in price per unit volume when compared to free-cutting brass.

Next to the addition of lead to aluminum, which he considers detrimental in many respects, H. Bohner considers to be most efficacious the addition of alloys forming intermetallic aluminum compounds not soluble in aluminum (for instance, silicon and zinc).

H. Kastner reports the newest results of his investigations on the alloys based on aluminum-copper-magnesium and aluminum-magnesium-silicon. In a series of diagrams he covers exhaustively the addition to these of sodium, potassium, lead, cadmium, copper and lead, and zinc and lead. He also gives new data on the $Al\text{-}Mg_3Sb_2$ diagram and the Al-Cr diagram.

Economical machining to a good surface condition is not only the concern of the metallurgist but also a problem for the manufacturer of automatic screw machines and cutting tools. This aspect was considered by H. Schallbroch and H. Opitz in their papers in the Aachen symposium. Three aspects of the problem are especially emphasized: (1) The cutting ability of the tool, (2) the form of the chip, and (3) the quality of the surface of the work piece. By temperature measurements at the cutting edge of the tool H. Schallbroch established that, depending on the cutting speed and cutting pressure, temperatures up to 250° C. are produced with brass and up to 300° C. and higher with light metals. It can be concluded from this that in lead-bearing alloys the desired short chips result from melting at the grain boundaries and consequent decrease in tensile strength. Thus the low tensile strength of the embedded lead plays an important part.

HANS DIEBGARTEN